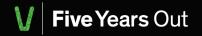
# Diodes Incorporated – Your Next Generation Supplier of Cost Effective Broad Based Power Management Solutions

Diodes Incorporated



- Introduction
- Diodes' Overview including Acquisitions
- Power Management
  - IC Product Solutions:
     AC:DC & DC:DC Switching Regulators, LDOs, Load/USB Power Switches, Current Monitors, Sync'FET drivers, Voltage References
  - Discrete Product Solutions:
     BJTs Optimized Gate Driver Products; MOSFETs; Super Barrier Rectifiers ("Next Gen' Schottky");
- Design Resources
   Application/Design Notes; Evaluation boards; Calculators; SPICE s/w

Public company (NASDAQ: DIOD, website: www.diodes.com)

- Founded in 1959
- Headquarters in Plano, TX; 21 locations globally
- North American, Asian, and European Inventory Location
- Manufacturing in U.S., UK, Germany, China and Taiwan
- ISO9001:2008 Certified / TS16949:2009 Certified ISO14001 Certified
- Acquired Anachip Corporation, Taiwan, 01/2006
- Acquired Advanced Power Devices, 11/2006
- Acquired Zetex, 06/2008
- Acquired Power Analog Microelectronics (PAM), 10/2
- Acquired BCD Semiconductor, 03/2013
- Over 5,500 employees worldwide



Five Years Out







#### Discrete

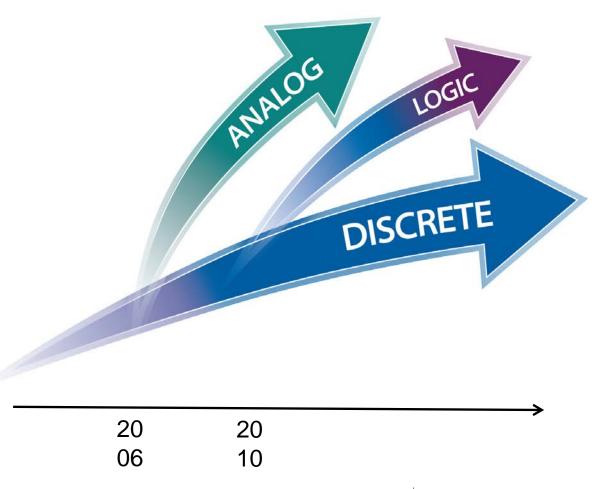
- Diodes
- MOSFETs
- Rectifiers
- Transistors
- Protection Devices

#### Analog

- Power Management
- Power Switches
- Standard Linear
- Sensors
- LED Drivers

#### Logic

- Low Voltage CMOS
- High Speed CMOS
- Advanced Ultra-Low Power CMOS























#### **Packaging**

- Shanghai-based packaging with capacity approximately 30 billion units
- Flexible and optimized manufacturing process = low packaging cost
- Additional packaging facilities in Neuhaus, Germany and JV in Chengdu, China





#### Wafer Fabs

- Bipolar process technology for discrete and ICs
- High volume 5" and 6" Wafer Fab in Kansas City, Missouri for discretes
- 6" Wafer Fab in Oldham, United Kingdom
- Two 6" Wafer Fabs in Shanghai for ICs (~50K/month capacity)









- Global function team support
- On site packaging design capability
- Teaming in new product development release
- Regional customer service
- Competitive costs
- Local management development











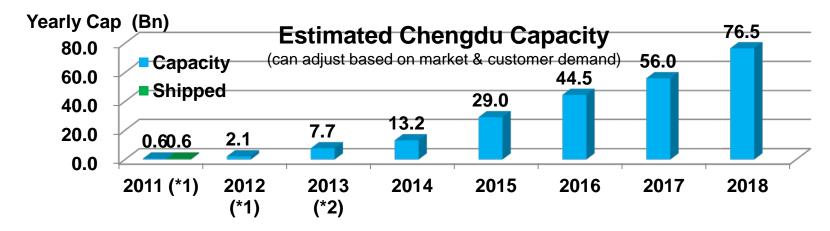


# Assembly + Test

- Yearly capacity of 76.5 billion units upon completion
- Flexible and optimized manufacturing process = low packaging cost



## Economies of Scale: Capacity Projection at Chengdu (bn)



- \*1 : RnD/Tuning/Optimization/reliability/training& trial run at Workshop
- \*2 : New factory ground breaking on 07/19/11, estimated start production from 2<sup>nd</sup> half 2012







Power Analog Microelectronics (PAM) is a provider of advanced analog and high- voltage power ICs. The company's product portfolio includes:

DC-DC converters

Class D audio amplifiers

LED backlighting drivers

PAM was founded in Silicon Valley in 2004 and has technical and business centers in Shanghai, Shenzhen, Taipei and Tokyo





#### A Strong Global Partnership



\$634m

2012 Gross Margin 25.1%

- High volume Discrete,
   Analog and Logic products
- Cost efficient packaging capabilities
- Strong global presence
- Broad product and customer base
- Consumer, computing and industrial focus



2012 Revenue

\$142m

2012 Gross Margin

27.5%

- Solid Standard Linear and Power Management offering
- Strong AC/DC Solutions for Switch-Mode Power Supply chargers and adaptors
- Cost effective China wafer fab capability and capacity
- Extensive China-based development team
- Strong China-local market position.

#### **SYNERGIES**

- Expanded application platform and broader Analog footprint
- Manufacturing synergies
- Operating synergies
- End equipment diversification
- Expanded customer base and distribution channels
- Expanded Asian position

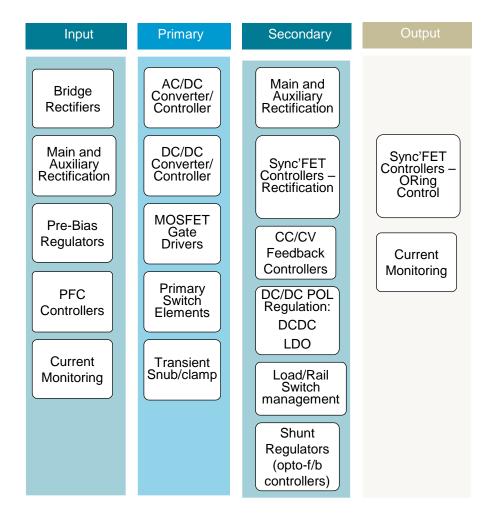
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\* 2012 Pro Forma Financials = 3Q 2012 YTD plus mid-point of 4Q 2012 guidance

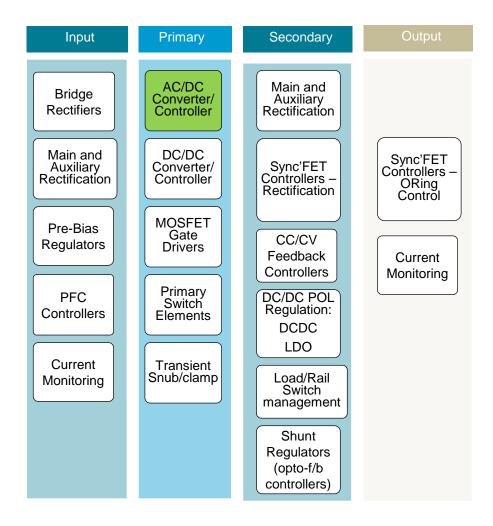
Discrete		Standard ICs	ASSP	
Diodes	Rectifiers	Standard Linear ICs	Power Management ICs	Sensors
Schottky Diodes	Schottky Rectifiers	Linear Voltage Regulators	DC-DC Switching Regulators	Unipolar Hall Switches
Zener Diodes	Super Barrier Rectifiers	Standard Linear Regulators	Buck	Bipolar Hall Latches
Switching Diodes	Standard Rectifiers	Quasi Low Dropout Regulators	Boost	Omnipolar Hall Switches
SBR® Diodes	Fast Recovery Rectifiers	Low Dropout Regulators	Buck/Boost/Inverter	Smart Fan Drivers
Power Zener Diodes	Bridge Rectifiers			Motor Controllers
Power Rectifier Diodes		Voltage References	AC/DC Solutions	Temperature Sensors
		Shunt References	Primary-Side Regulators	Magnetic Sensors
		Micropower References	PWM	_
MOSFETs	Protection Devices		BJT Switches	
Small Signal MOSFETs	TVS	Current Monitors	Constant Current / Constant Voltage	
Power MOSFETs	Low CJ TVS	Current Output	•	
Protected MOSFETs	Thyristor Surge Protection	Voltage Output	Power Switches	Digital Broadcast by Satellite
High Voltage MOSFETS	Data Line Protection	vollage output	Load Switches	Fixed Bias Generators
Complementary Pairs		Operational Amplifiers	USB Switches	Switched Rias Generators
H-Bridges		operational variations	oob omisies	Multiplex Controllers
IntelliFET®		Comparators	LED Drivers	Integrated Switch Matrix
		5511,441,411	Charge Pump	DBS Interface
Bipolar Transistors	Function Specific Arrays	Special Functions	Boost	STB Power
Small Signal BJT	Relay Drivers	Timer IC	Buck	
Pre-biased BJT	Discrete Load Switches	Reset Generators	Linear LED Drivers	
Medium Power BJT	Discrete Voltage Regulators	Siren Drivers	LED backlighting	
High Power BJT	MOSFET Gate-Drivers	Low Power Motor Control		
Darlington Transistors		Current Mirror	Power Supply	
Gate-Drivers			MOSFET Controllers	Audio
Low Saturation BJT		Standard Logic ICs	Active OR-ing Controllers	Class D Amplifiers
H-Bridges		Single Gate	Chargers	Analog Input Amplifiers
		Enhanced Single Gate		
		Dual Gate		
		Standard Logic		

Legend: White-Diodes Only; Pink-BCD Only; Blue-Synergistic

IntelliFET and SBR are the registered trademark of Diodes Incorporated and its affiliates.









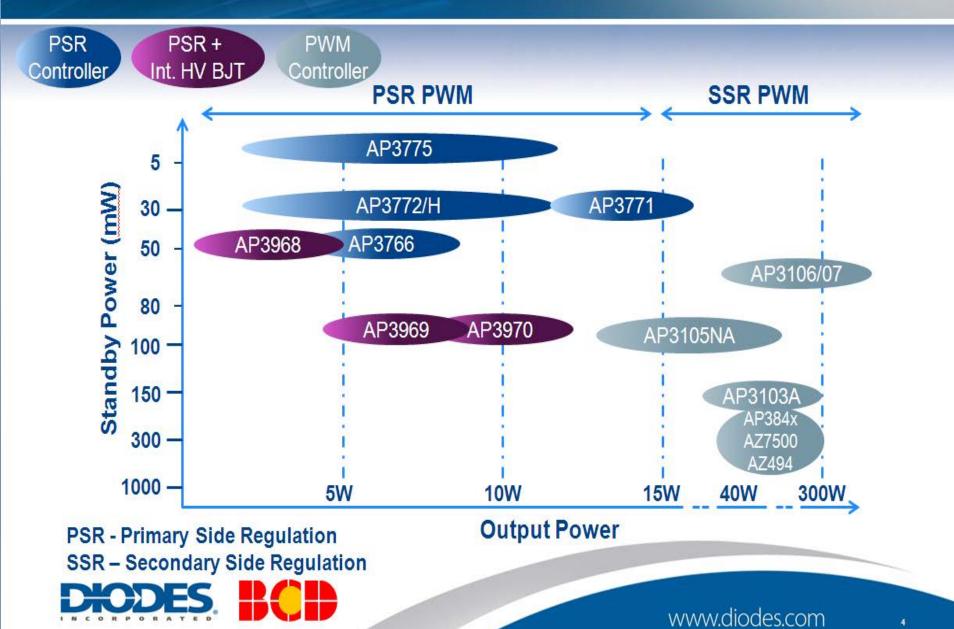
# **Diodes AC-DC Products Overview**







# Standby Power vs Output Power



# Example - AP3105 - Green Mode PWM Controller

17

#### Main Features

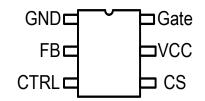
- ➤ Ultra low start-up/operating current: 5µA/1.35mA
- Frequency dithering for low EMI
- Ultra low standby (100mW less)
- > Audible noise free
- Versatile latch/auto-recoverable protection mode
- > VCC maintain mode
- > Fast OCP
- Constant over load protection (saw limiter)
- > Pin fault protection
- Fixed 65kHz/100kHz oscillator frequency
- > Meet EPS 2.0 requirement
- ➤ Pin to pin compatible with <u>RT7732</u>, <u>OB2273</u>, <u>LD7536</u>

#### **Product Table Product Version** Frequency VOVP OLP& SOCP CTRL (Low) CTRL (High) Auto-Recoverable Auto-Recoverable Auto-Recoverable AP3105 65kHz Latch AP3105V 65kHz Latch Auto-Recoverable Latch Latch AP3105L 65kHz Latch Latch Latch Latch 65kHz Auto-Recoverable Auto-Recoverable Auto-Recoverable Latch

## **Major Applications**

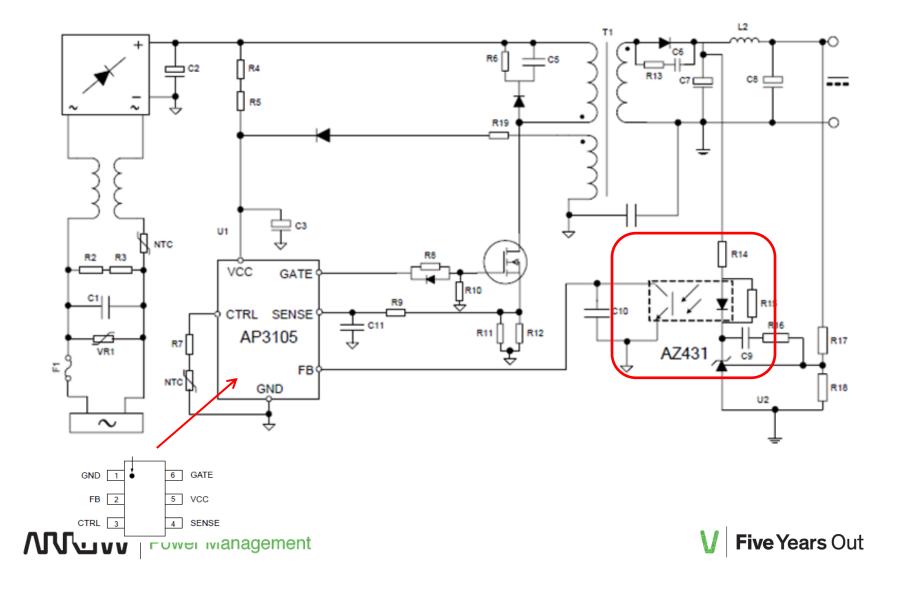
➤ 40W or less power applications for STB, DataCom, NetBook, etc

#### Pin-out



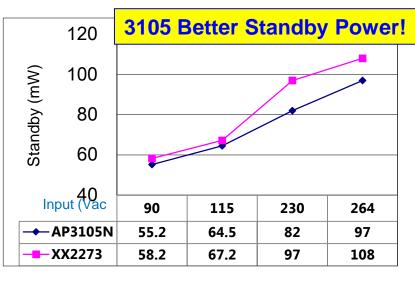


Five Years Out



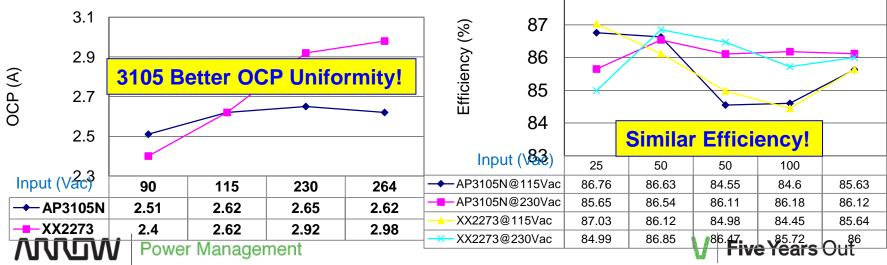
# **AP3105N Performance on a 32W Adaptor**

19



#### S/N:19V32W ADP





#### AP3968 main Features

Power switcher with primary side control

Built-in NPN Transistor with 700VCBO

Built-in line compensation for  $\pm$  7% current tolerance

Built-in cable compensation for  $\pm$  5% voltage tolerance

100mW less Standby power

EPS 2.0 compliant with higher margin

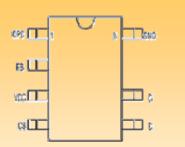
Built-in OVP/OTP/OCP/SCP functions

Meet HV creepage requirements

Low cost solution for its less component count

Applications: Adapters/Charger/Small appliance

Output Power: 4.5W adapter with case under 90V~264VAC input





#### AP3969/70 main Features

Power switcher with primary side control

Built-in NPN Transistor with 700VCBO

Built-in line compensation for  $\pm$  7% current tolerance

Built-in cable compensation for  $\pm$  5% voltage tolerance

100mW less Standby power

EPS 2.0 compliant with higher margin

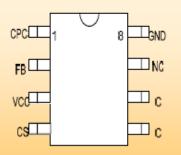
Built-in OVP/OTP/OCP/SCP functions

Meet HV creepage requirements

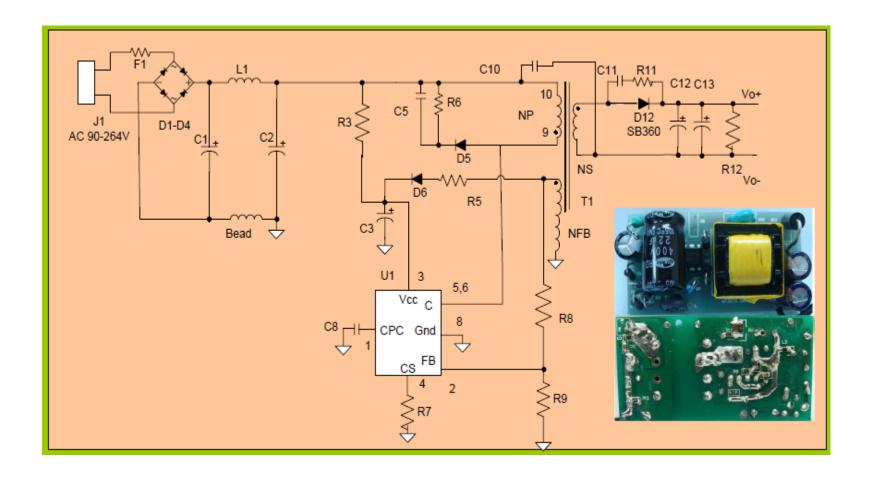
Low cost solution for its less component count

Applications: Adapters/STB/Home appliances

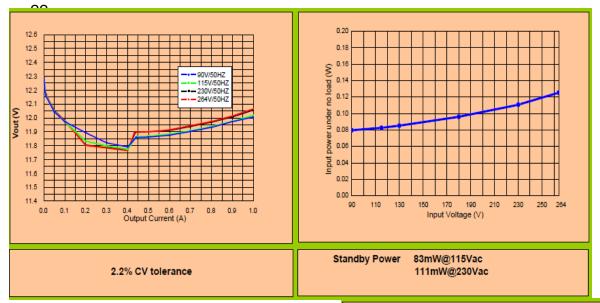
Output Power: 7.5W(AP3969)/12W(AP3970) adapter with case under 90V~264VAC input

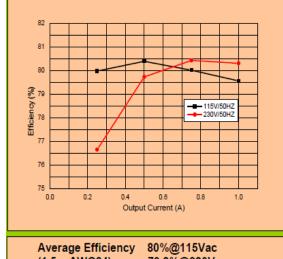


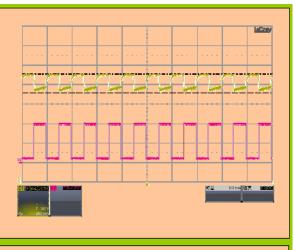




# AP3970 12V/1A Eval' Board







79.3%@230Vac (1.5m AWG24)

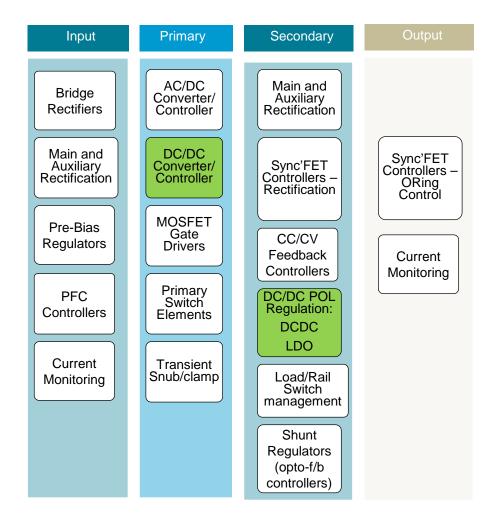
Dynamic Load of 12V/1A, 0.1-1A(CC mode)50Hz Vo: 11.6V-12.5V





# **All Applications**





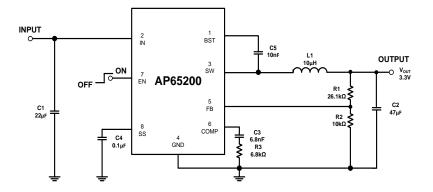


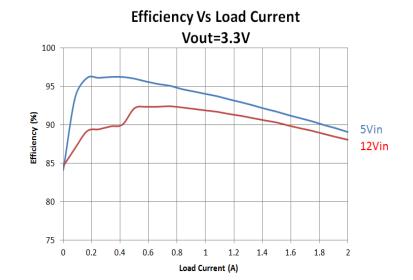
## AP65200

# 2A 4.75V to 18V Synchronous DC-DC Buck Converter With Light Load High Efficiency

#### The Diodes Advantage

- Compact High-Performance DC-DC Converter The AP65200 enables 2A of continuous load current with efficiency as high as 96%.
- Light Load High Efficiency
   Enables efficiency above 85% down to 20mA load current
- Reduced External Component Count
   In the AP65200 Diodes has integrated low R<sub>DSON</sub> high side and low side switches to remove the need for an external Schottky diode reducing external component count
- Package
   AP65200 comes in a standard SO-8 package [5x6mm]
   (DFN3030-10 is planned to be release Q1-2013 [3x3mm])
- Self Protection
   Integrated fixed current limit and with on-board self protection against thermal damage and short-circuit.





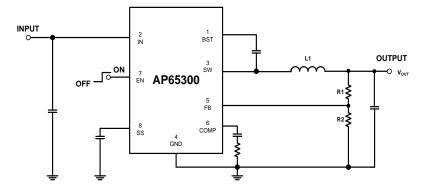
Pin to Pin compatible to AP6502 adding light load high efficiency

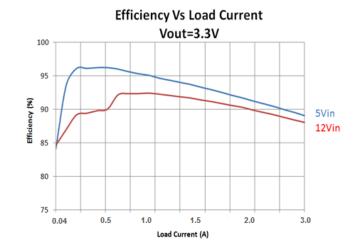
AP65300

# 3A 4.75V to 23V Synchronous DC-DC Buck Converter With Light Load High Efficiency

#### The Diodes Advantage

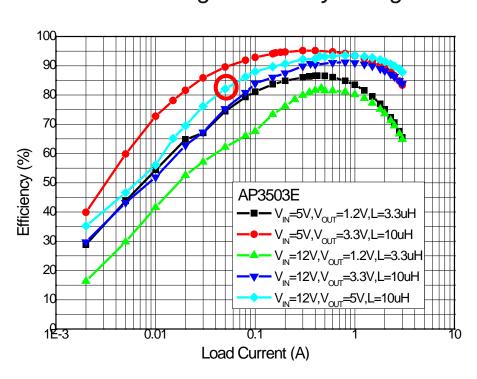
- Compact High-Performance DC-DC Converter
   The AP65300 enables 3A of continuous load current with efficiency as high as 96%.
- Light Load High Efficiency Enables efficiency above 85% down to 30mA load current
- Reduced External Component Count In the AP65300 Diodes has integrated low R<sub>DSON</sub> high side and low side switches to remove the need for an external Schottky diode reducing external component count
- Switching Frequency Options AP65300 340kHz, AP65301 500kHz
- Package
   AP65300 comes in a standard SO-8EP package [5x6mm]
   and DFN3030-10 [3x3mm]
- Self Protection
   Integrated fixed current limit and with on-board self protection
   against thermal damage and short-circuit.





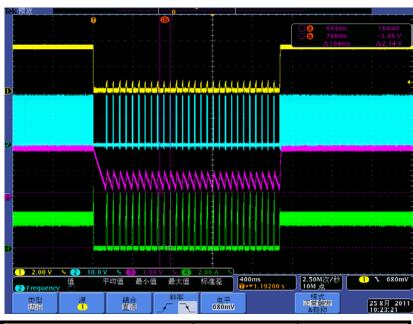
Pin to Pin compatible to AP6503 adding light load high efficiency

PSM- - -> High Efficiency @ Light Load



 $(12V_{IN} \text{ to } 5V_{OUT} @ 40\text{mA} \rightarrow 80\%)$ 

#### Hiccup Short Circuit Protection



Tc (°C)\Vo=3.3V	Vin=5V	Vin=12V
Hiccup	46 °C	47 °C
Non-Hiccup	114 °C	123 °C

### 2A/3A Product AP3512/3E

- 2A/3A output current with same pin out as AP3502/3 (MP1482/84)
- Fixed 500kHz to use smaller inductor and capacitor
- Power saving mode to achieve high efficiency at light load
- Output short circuit hiccup mode protection

Vin=12V	Vo=5V	Vo=3.3V	Vo=2.5V	Vo=1.8V	Vo=1.5V	Vo=1.2V
Io=3A	4.7uH	3.3uH	2.2uH	2.2uH	2.2uH	2.2uH
lo=2A	3.3uH	3.3uH	1.5uH	1.5uH	1.5uH	1.5uH
lo=1A	2.2uH	1.5uH	1.5uH	1uH	1uH	1uH

## 3A Product AT5503

- 3A output current with same pin out as AP3503
- 500kHz to use smaller inductor and capacitor
- 0.8V reference voltage(VFB) to meet lower core voltage requirement
- Power saving mode to achieve high efficiency at light load

# High Voltage Cross Reference DC-DC Converters

DC-DC Buck Converters				
AP5100	MP2359	MPS	Pin-to-pin compatible, we need a capacitor in parallel to R1 of the feedback voltage divider	
	RT8259	Richtek	Pin-to-pin compatible	
AP6502 AP3502	MP2305	MPS	Pin for pin replacement VIN 23V	
	MP1482	MPS	Pin-to-pin compatible	
	RT8252A	Richtek	Pin-to-pin compatible VIN 4.5-18V	
AP6503 AP3503	MP2307	MPS	Pin-to-pin compatible	
	MP1484	MPS	Pin-to-pin compatible	
	RT8250	Richtek	Pin-to-pin compatible	
	RT8253A	Richtek	Pin-to-pin compatible	
AP6507	MP8707	MPS	Pin-to-pin compatible	
AP6508	MP28253	MPS	Pin-to-pin compatible	
AP65200 AP3502E	MP2305	MPS	Pin for pin replacement VIN 23V, we have LLHE	
	MP1482	MPS	Pin-to-pin compatible, we have LLHE	
	RT8252A	Richtek	Pin-to-pin compatible VIN 4.5-18V, we have LLHE	

LLHE - Light Load High Efficiency

# AP3417B 1.4MHz 1.2A Step-Down

31

#### **Features**

- 1.2A load current
- High efficiency: up to 95%
- Input voltage range: 2.5V-5.5V
- 1.4MHz switching frequency
- Pulse skipping at light load with low threshold current
- Low threshold current at light load
- Input OVP function
- Support output capacitor 4.7uF
- Excellent line and load regulation
- 100% duty cycle
- Built-in OVP,OCP,OTP,SS

# **Applications**

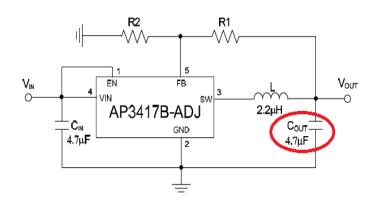
- Notebook, LCD-TV, WIFI Module
- USB 3.0 Pen drive/STB/ Datacom
- Portable Device , Tablet PC

#### Cross Reference

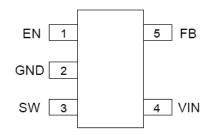
AP3417B P2P with AP3417C/AP3410
 APW7102/UP6302/AX3513BT/RT8024/ RT8059

# Nover Management

# Application Circuit



# Package & Pin Map



SOT 23-5



# AP3408 4MHz 2A Step-Down

32

#### Features

- 2A load current
- Input voltage range: 2.6V-5.5V
- High Efficiency up to 95%
- Programmable Freq from 300kHz to 4MHz
- Synchronized external clock
- Power Good output voltage monitor
- Excellent line and load regulation
- 100% duty cycle
- Built-in UVLO,OCP,OTP,SS

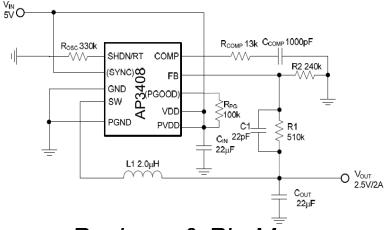
# **Applications**

- Portable Device, Data Card
- Wireless Device/NB
- Networking/LCD TV/STB

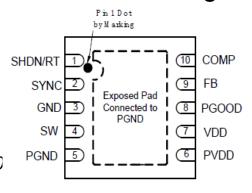
#### Cross Reference

P2P compatible to RT8011/RT8015/RT8030

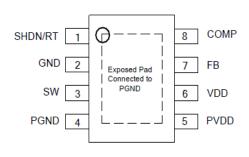
# Application Circuit



Package & Pin Map



DFN3030-10



SOP-8(EP)





# PAM2320 1.5MHz 3A Step-Down Converter

33

#### Features

- 3A load current
- High efficiency: up to 95%
- Input voltage range: 2.7V-5.5V
- <u>1.5MHz switching frequency</u>
- Pulse skipping at light load
- Only 42uA Quiescent Current(IQ)
- Excellent line and load regulation
- 100% duty cycle
- Built-in UVLO,OCP,OTP,SS

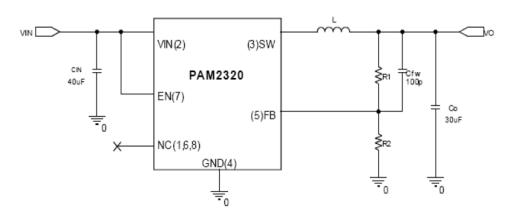
## **Applications**

- LCD-TV, STB
- Networking
- DVR, GPS

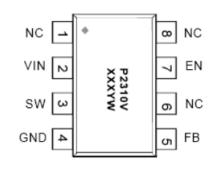
#### Cross Reference

• P2P compatible to MP1484/AP3503

# Application Circuit



## Package & Pin Map



SOP-8

V Five Years Out

# AP3433 2MHz 3A Step-Down

34

#### **Features**

- 3A load current
- Input voltage range: 2.95V-5.5V
- High Efficiency up to 94%
- Programmable Freq from 300kHz to 2MHz
- Synchronized external clock
- Adjustable Soft Start
- <u>UV and OV power good indication</u>
- Hiccup for SCP protection
- Built-in UVLO, OVP, OCP, OTP

## **Applications**

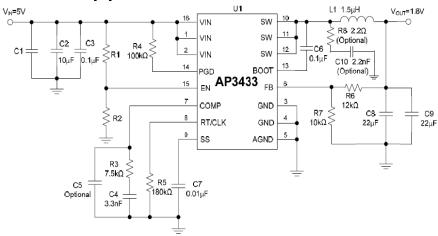
- LCD TV/STB
- Networking
- DVR, GPS
- Post DC-DC Voltage Regulation

#### Cross Reference

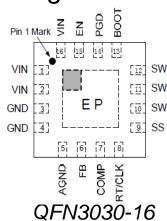
 P2P compatible to TPS54318/TPS54319/RT8079/G5173



## **Application Circuit**



## Package & Pin Map



V Five Years Out

# AP3436 1.25MHz 3A Step-Down

35

#### Features

- 3A load current
- Input voltage range: 3V-5.5V
- High Efficiency up to 95%
- 1.25MHz switching frequency
- UV and OV power good indication
- Output OVP/UVP protection
- Excellent line and load regulation
- Built-in UVLO, OVP, UVP, OCP, OTP, SS

# **Applications**

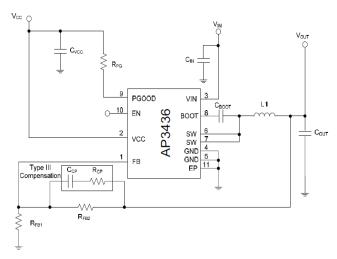
- VGA for DT/NB
- LCD TV/STB
- Networking
- Post DC-DC Voltage Regulation

#### Cross Reference

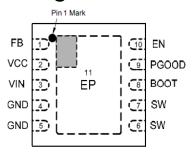
• P2P compatible to RT8071



# Application Circuit



# Package & Pin Map



DFN3030-10



# AP3409A 4MHz 3A Step-Down

36

#### **Features**

- 3A load current
- Input voltage range: 2.6V-5.5V
- High Efficiency up to 95%
- Programmable Freq from 300kHz to 4MHz
- Power Good output voltage monitor
- Hiccup for SCP protection
- Excellent line and load regulation
- 100% duty cycle
- Built-in UVLO,OCP,OTP,SS

# **Applications**

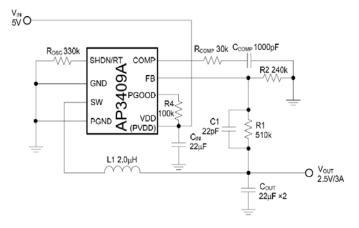
- Portable Device, Data Card
- Wireless Device/NB
- Networking/LCD TV/STB

#### Cross Reference

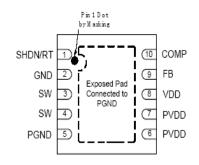
P2P compatible to RT8015A/B/D, RT8055/B

# NOTE Power Management

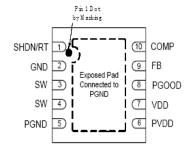
# Application Circuit



## Package & Pin Map







DFN3030-10



Five Years Out

# PAM2327 1.2MHz 3.5A Step-Down

37

#### Features

- 3.5A load current
- Input voltage range: 2.5V-5.5V
- 1.2MHz switching frequency
- Pulse skipping at light load
- Only 55uA Quiescent Current(IQ)
- Power good indicator
- Hiccup mode for SCP protection
- Excellent line and load regulation
- Excellent load transient response
- 100% duty cycle
- Built-in UVLO,OCP,OTP,SS

# **Applications**

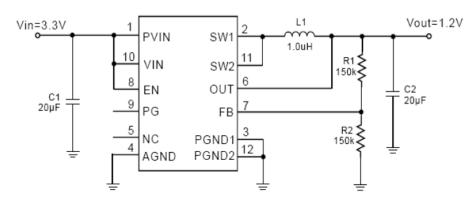
- WIFI Module, Data Card, LTE Devices
- SSD/HDD/Smart Phone
- Portable Devices

### Cross Reference

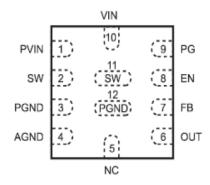
P2P compatible to MP2130/MP9180

# Nover Management

# Application Circuit



# Package & Pin Map



QFN2020-12



## AP3440 2MHz 4A Step-Down

38

#### Features

- 4A load current
- Input voltage range: 2.95V-5.5V
- High Efficiency up to 94%
- Programmable Freq from 200kHz to 2MHz
- Synchronized external clock
- Adjustable Soft Start
- UV and OV power good indication
- Hiccup for SCP protection
- Built-in UVLO, OVP, OCP, OTP

### **Applications**

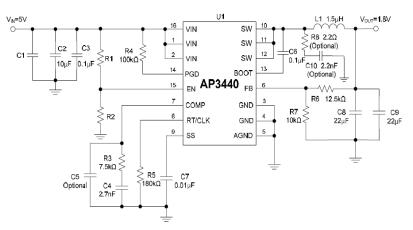
- LCD TV/STB
- Networking
- DVR, GPS
- Post DC-DC Voltage Regulation

#### Cross Reference

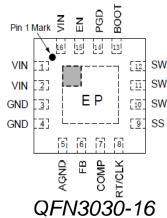
P2P compatible to TPS54418/G5172

## ower Management

## Application Circuit



### Package & Pin Map





## AP3427 1.5MHz 1A/1A Dual

39

#### Features

- 1A /1A load current
- Input voltage range: 2.5V-5.5V
- 1.5MHz switching frequency
- <u>Pulse skipping at light load with low threshold</u> current
- Low threshold current at light load
- Input OVP function
- Excellent line and load regulation
- 100% duty cycle
- Built-in OVP,OCP,OTP,SS

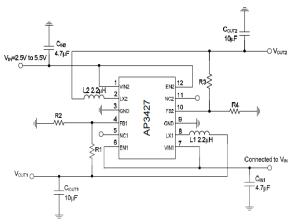
## **Applications**

- WIFI Module/SSD
- USB 3.0 Pen drive
- Portable Devices

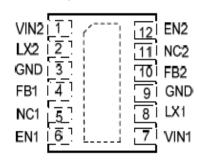
#### Cross Reference

Pin compatible to RT8020/G5699

## Application Circuit



### Package & Pin Map



DFN3030-12



## LV Buck Converter Product

40

Part	I <sub>OUT</sub> (Max) (A)	V <sub>IN</sub> Range (V)	V <sub>OUT</sub> (V)	Feedback Voltage (V)	Switch Frequency (kHz)	Package	Highlight	Cross Reference
AP3417C	1	2.5 to 5.5	ADJ/Fix	0.6	1500	SOT25 DFN2020-6	Input OVP, PSM	SY8008/SY8088/APW7102/UP6302/AX351 3BT/RT8024/ RT8059
PAM2304	1	2.5 to 5.5	ADJ	0.6	3000	SOT25 DFN2020-6	High Fs, Low IQ, PSM	SY8008/SY8088/APW7102/UP6302/AX351 3BT/RT8024/ RT8059
AP3410	1.2	2.5 to 5.5	ADJ/Fix	0.6	1500	SOT25 DFN2020-6	Input OVP, PSM	SY8008/SY8088/APW7102/UP6302/AX351 3BT/RT8024/ RT8059
AUR9705B	1.2	2.5 to 5.5	ADJ/Fix	0.6	1500	SOT25	Input OVP, PSM	RT8025/PAM2305/APW7105
AP3417B	1.2	2.5 to 5.5	ADJ	0.6	1400	SOT25	Support 4.7uF Cout, IOVP,PSM	SY8008/SY8088/APW7102/UP6302/AX351 3BT/RT8024/ RT8059
AP3418	1.5	2.5 to 5.5	ADJ	0.6	1400	SOT25	PSM	SY8009A
PAM2310	2	2.7 to 5.5	ADJ	0.6	1500	SO-8	High Fs, Low IQ, PSM	MP1482/AP3502/AP65200
PAM2321	2	2.7 to 5.5	ADJ/1.2 V	0.6	3000	DFN3030-10	High Fs, Low IQ, PSM	RT2652
AP3408	2	2.6 to 5.5	ADJ	0.8	300 to 4000, Sync	DFN3030-10 SO-8(EP)	PG, Sync Ext clock, Fs Adj	RT8011/RT8015/RT8030
AP3431	2	2.7 to 5.5	ADJ	0.8	1000	SO-8		G5626/G5692/AT1528/AX3514B
AUR9718B	2.5	2.7 to 5.5	ADJ	0.8	1500	DFN3030-6	Input OVP, PSM	MP2012





# LV Buck Converter Product List(3A~4A, Dual)

41

Part	I <sub>OUT</sub> (Max) (A)	V <sub>IN</sub> Range (V)	V <sub>OUT</sub> (V)	Feedback Voltage (V)	Switch Frequency (kHz)	Package	Highlight	Cross Reference
PAM2303	3	2.7 to 5.5	ADJ	0.6	1500	SO-8(EP) DFN3030-10 QFN3030-16	Low IQ, PSM	AAT2153/AAT2114A
PAM2320	3	2.7 to 5.5	ADJ	0.6	1500	SO-8(EP) High Fs, Low IQ, PSM		MP1484/AP3503/PAM2310
AP3433	3	2.95 to 5.5	ADJ	0.827	300 to 2000, Sync	QFN3030-16	PG, Sync ext clock, Fs Adj	TPS54318/9, RT8079, G5173
AP3436	3	3.0 to 5.5	ADJ	0.6	1250	DFN3030-10	PG	RT8071
AP3409A	3	2.6 to 5.5	ADJ	0.8	300 to 4000	DFN3030-10	PG, Fs Adj	RT8015A/B/D, RT8055/B
PAM2325	3.5	2.5 to 5.5	ADJ	0.6	1200	QFN2020-12	PG, Hiccup, Low IQ, PSM	MP2130/MP9180
AP3435	3.5	2.7 to 5.5	ADJ	0.8	1000	SO8(EP)	Input OVP, PSM	G5627/G5694/AT1530
AP3440	4	2.95 to 5.5	ADJ	0.803	200 to 2000, Sync	QFN3030-16	PG, Sync ext clock, Fs adj	TPS54418/G5172
AP3427M	1A/1A	2.5 to 5.5	ADJ	0.6	1500	DFN3030-10	Input OVP, PSM	ITE7117, APW7139
PAM2306 D	1A/1A	2.5 to 5.5	ADJ	0.6	1500	DFN3030-12	Low, IQ, PSM	RT8020/G5699
AP3427	1A/1A	2.5 to 5.5	ADJ	0.6	1500	DFN3030-12	Input OVP, PSM	RT8020/G5699
PAM2311	2	2.7 to 5.5	ADJ	0.6	1500	SOT25	High Fs, PSM	SY8009

Power Management



Function	AP7311	AP7313	AP7115	AP7331	AP7333	AP7335	AP7335A	AP7340	AP7332
Vin Range	2.0~6.0	2.0~6.0	2.5~5.5	2.0~6.0	2.0~6.0	2.0~6.0	5.5~6	1.0~5.5	2.0~6.0
Output Current	150mA@	2150mV	150mA@200mV	300mA@	2300mV	300mA@150m V	300mA@150m V	150mA@150m V	300mA@300m V
PSRR	65dB@100H z	65dB@100H z	70dB@1KHz	65dB@100H z	65dB@100H z	65dB@1KHz	65dB@1KHz	75dB@1KHz	65dB@1KHz
EN	V		V	V		V	٧	V	٧
РОК									
ADJ	V		V	V	V	V	V	V	
Fixed Output		1.0/1.2	/1.5/1.8/2.0/2.5/2.8	/3.0/3.3		0.8V~3.9V	5.0V	1.2V~3.3V	refer to DS
IQ	55uA	55uA	50uA	55uA	55uA	35uA	35uA	36uA	60uA
Package	SOT25	SOT23	SOT25 SOT353	SOT25 DFN2020-6	SOT23 SOT23R	SOT25 DFN2020-6	SOT25 DFN2020-6	DFN1010-4	SOT26 DFN2018-6
Remark			BP Pin Available for Noise Reduction					Mar'13 RTP	





# CMOS LDO Product List(0.6A~3A)

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P/N	AP7217	AP7165	AP7365	AP7167	AP7361	AP7362	AP7363	AP7175	AP7176B	AP7173
Vin Range	3.3~5.5	2.2~5.5	2.0~6.0	2.2~5.5	2.2~6.0	2.2~5.5	2.2~5.5	1.2~3.65	1.2~5.5	1.0~5.5
Output Current	500mA@600m V	500mA@300m V	600mA@300mV	1A@500mV	1A@500mV	1.5A@220 mV	1.5A@220m V	3A@230mV	3A@300mV	1.5A@165m V
PSRR	55dB@1KHz	60dB@1KHz	65dB@1KHz	60dB@1KH z	65dB@1KH z	58dB@1KH z	58dB@1KHz	67dB@1KHz	67dB@1KH z	60dB@1KHz
EN	V	V	V	V	v	V		V	V	v
РОК		V		V				V	V	v
ADJ		V	V	V	٧	V	V	V	V	v
Fixed Output	3.3V		1.0V~3.9V		V	v	V			
SS								V		V
Package	SOP-8L	DFN3030-10 SOP-8L-EP	DFN2020-6, SOT25, SOT89-3L, SOT89R-3L, SOT223-3L, SOT223R-3L	DFN3030- 10 SOP-8L-EP	SOT89 DFN3030E	SOP-8L-EP DFN2030-8	SOT223-3 SOP-8L-EP DFN2030-8	SOP-8L MSOP-8L	SOP-8L MSOP-8L	DFN3030-10 SOP-8L-EP
Remark	Reset Output						se Output: Vrms			

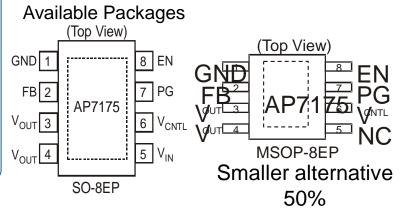
## AP7175/7176B 3A Ultra Low Dropout with ENABLE

#### The Diodes Advantage

- Ultra Low Dropout at 3A Continuous Current from -40 °C to +85 °C
   Stable conversion at very low dropout, 0.23V, such as 1.5V to 1.2V or 1.8V to 1.5V over industrial temp. range.
- 1.5% Output Accuracy over Industrial Temp.
   Range
   Maintain accuracy over all conditions
- High PSRR with 67dB at 1KHz
   Ensure low noise high quality supplies for analog circuits such as audio, video and RF applications.
- Low Shutdown Current at 15uA(typ.) Offer power saving in low-power and battery operated products.

p2p compatible with Anpec APL5930



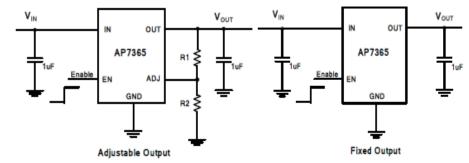


### AP7365/7335

0.6/0.3A Low Quiescent Current, Fast Transient Ultra-Low Dropout Linear Regulato

- Low Dropout at 0.6A/0.3A Continuous Current from -40 °C to +85 °C Stable conversion at very low dropout such as 3.3V to 2.8V/2.5V or 2.5V to 1.8V over industrial temp. range.
- 2% Output Accuracy over Industrial Temp. Range Maintain accuracy over all conditions
- High PSRR with 65dB at 1KHz
   Ensure low noise high quality supplies for analog circuits such as audio, video and RF applications.
- Low Quiscent Current at 35uA
   Offer power saving in low-power and battery operated products.





### AP7361

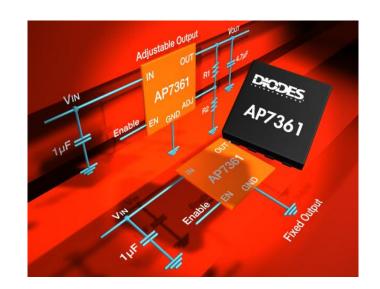
# 1A Low Dropout Adjustable and Fixed Regulator with Enable

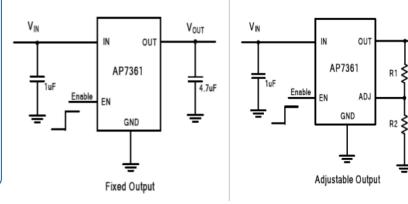
#### The Diodes Advantage

 Low Dropout at 1.0A Continuous Current from -40 °C to +85 °C

Stable conversion at very low dropout such as 3.3V to 2.8V/2.5V or 2.5V to 1.8V over industrial temp. range

- 70µA Quiescent Current and 0.1µA Shutdown Current Increases the efficiency and utilizes the enable pin turn increasing system savings when parts of a system are not required.
- DFN3030E-8 Industrial Standard Package Available Smaller package dimension but better power dissipation efficiency(ex: DFN3030(1.7W) vs TO252(1.25W)).
- Self Protected with Thermal Shutdown,
   Current Limiting and Short-Circuit Feature
   Prevents system shutdown/restart and improve system robustness.



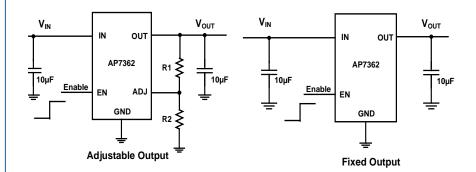


### AP7362/3

1.5A Low Quiescent Current, Fast Transient Ultra-Low Dropout Linear Regulator

- Ultra Low Dropout 190mV at 1.5A Continuous Current from -40 °C to +85 °C
   Increase system performance and efficiency
- Low Output Noise, 90uVrms(100~100KHz, Cout=10uF) Excellent output noise performance which AP7362/3 provides is perfectly suitable for critical signal, such as video, audio applications.
- DFN2030E-8 Industrial Standard Package Available Smaller package dimension but better power dissipation efficiency
- Self Protected with Thermal Shutdown, Current Limiting and Short-Circuit Feature Prevents system shutdown/restart and improve system robustness.





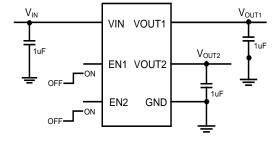
## AP73x2

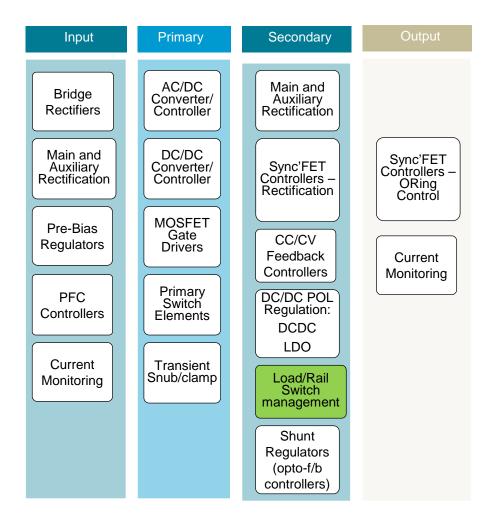
# Dual 150 / 300mA Low Quiescent Current Fast Transient Low Dropout Linear Regulator

- Small Industrial-Standard DFN2018-6 and SOT26 Package Reduces board space requirements and increases layout flexibility.
- 60µs Fast Start-up Time
   Allows for fast system response from standby or sleep mode.
- 60uA Quiescent Current Increases system performance and efficiency.
- Thermal Shutdown, Short-Circuit and Over-Current Protection Improve robustness of circuit and prevents pre-mature failure.

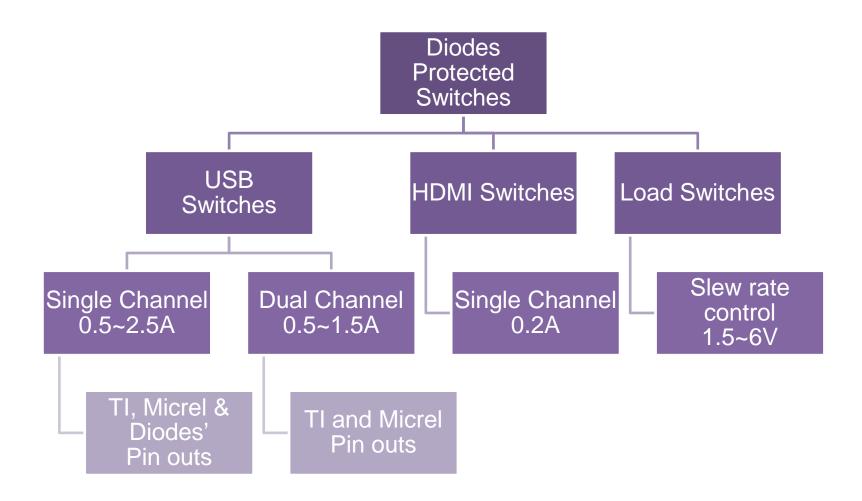
		Output	QuiescentC	urrent	Ambient	
Part #	Output Voltage	Current	Operation	Stby	Temp	Package
AP7312	1.2V/1.8V, 1.2V/3.3V, 1.5V/2.5V, 1.5V/3.3V , 1.8V/2.8V, 1.8V/3.0V, 1.8V/3.3V, 3.3V/3.3V	150 / 150 mA	60 µA	0.1 μΑ	-40 to +85 ° C	SOT26 DFN2018-6
	1.0V/1.0V, 1.0V/3.3V, 1.2V/1.8V, 1.2V/3.3V, 1.5V/2.8V, 1.5V/3.0V, 1.5V/3.3V, 1.8V/2.8V, 1.8V/3.0V, 1.8V/3.3V, 2.5V/3.0V, 2.8V/3.3V 3.3V/3.3V	300 / 300 mA	60 µA	0.1 μΑ	-40 to +85 ° C	SOT26 DFN2018-6















#### **USB V<sub>BUS</sub> Over-Current Protection** Single Channel USB Switches **Dual Channel USB Switches** AP2141/41D/45/51/51D/55 $\rightarrow$ 1ch at 0.5A AP2142/42A/46/52/52A/56 $\rightarrow$ 2ch at 0.5A AP2161/61D/71/71D/2337 $\rightarrow$ 1ch at 1A or 2ch at each → 2ch at 1A each 0.5A AP2162/62A/66/72/72A/76 AP2181/81D/91/91D → 1ch at 1.5A or 3ch at AP2182/82A/86/92/92A/96 $\rightarrow$ 2ch at 1.5A 0.5A each AP2101/11/2301/11/2401/11 $\rightarrow$ 1ch at 2A or 2ch at 1A AP255xx → multiple channels AP2501/11D → 1ch at 2.5A **YUKI YUKI** $V_{\mathsf{BUS}}$ $V_{BUS}$ USB USB D+ D+ CONTROLLER CONTROLLER OR D-D-**GND** GND SDA004 BZT52 C6V2 DLPT05 I/O ESD Protection BAV99/99W/99DW, BAT54S SDA004, QSBT40





Pai Numl		Max Cont. Output Current	Ĭ	Enable Logic (Active)	Min Op Voltage		9	$R_{DS(ON)}$ $(V_{IN} = 5V)$	Output Discharge	OCP Output Latch Off	OCP Flag	Adj. I∟ıм	Ambient Temp Range	Package Outlines
		А	А	Low	V	V	μΑ	mΩ					°C	MSOP-8/EP, SO-8, U-
AP2501	(11)	2.5	4.6	(High)	2.7	5.5	60	70	Υ		Υ		-40 to +85	DFN3030-8
AP2552	(53)	2.1	2.35	Low (High)	2.7	5.5	100	70	Υ		Υ	Y	-40 to +85	SOT26, U-DFN2020C-6
AP2552 A	(53A)	2.1	2.35	Low (High)	2.7	5.5	100	70	Υ	Υ	Υ	Υ	-40 to +85	SOT26, U-DFN2020C-6
AP2301	(11)	2	2.85	Low (High)	2.7	5.5	60	70	Υ		Υ		-40 to +85	MSOP-8EP, SO-8, U- DFN3030-8
AP2401	(11)	2	2.5	Low (High)	2.7	5.5	60	70	Υ	Υ	Υ		-40 to +85	MSOP-8EP, SO-8, U- DFN3030-8
AP2101	(11)	2	2.8	Low (High)	2.7	5.5	45	90	Υ		Υ		-35 to +85	MSOP-8EP, SO-8
AP2181 D	(91D)	1.5	2.6	Low (High)	2.7	5.5	45	90	Υ		Υ		-40 to +85	MSOP-8/EP, SO-8, SOT25, U-DFN2018-6
AP2181	(91)	1.5	2.6	Low (High)	2.7	5.5	45	90			Υ		-40 to +85	MSOP-8EP, SO-8, SOT25, U-DFN2018-6
AP2161 D	(71D)	1	1.9	Low (High)	2.7	5.5	45	90	Υ		Υ		-40 to +85	MSOP-8EP, SO-8, SOT25, U-DFN2018-6
AP2161	(71)	1	1.9	Low (High)	2.7	5.5	45	90			Υ		-40 to +85	MSOP-8EP, SO-8, SOT25, U-DFN2018-6
AP2141 D	(51D)	0.5	1	Low (High)	2.7	5.5	45	90	Υ		Υ		-40 to +85	MSOP-8EP, SO-8, SOT25, U-DFN2018-6
AP2141	(51)	0.5	1	Low (High)	2.7	5.5	45	90			Υ		-40 to +85	MSOP-8EP, SO-8, SOT25, U-DFN2018-6

## AP2552/53/52A/53A

# 75mA ~ 2.35A Adjustable current-Limit Power Switch with/out Latch-Off

#### The Diodes advantage

The AP2552/53/52A/53A provide fast and accurate adjustable over-current protection for improved USB ports protection

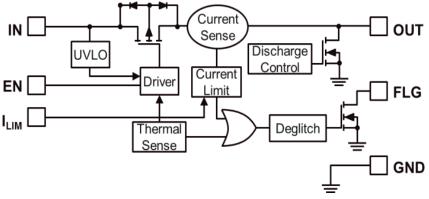
- ±6 percent current-limit accuracy at 1.5 A
  Allows closer matching of current limits to system requirements; reducing unnecessary overheads
- Adjustable current limit from 75 to 2,350mA
   Single device used across platforms, with just a resistor change
- Constant current (AP2552/3) and latch-off (AP2552A/3A) versions

Fault behavior can be optimized for different designs

- Fast transient response time: 2μs
   Prevents unnecessary system shutdown or restart
   → improves system robustness
- Reverse current blocking/limiting, UVLO, over-current, overtemperature, and short-circuit protection

Improves robustness of USB ports



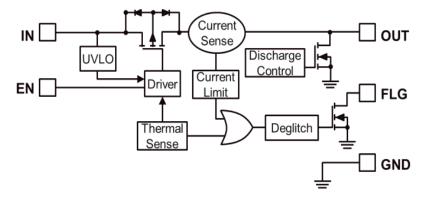


## AP2501 and AP2511

# 2.5A Single Channel Current-Limited Power Switch

- Low Thermal Resistance
   The exposed pad SO-8EP/MSOP-8EP packages provide lower junction temperature and more reliable solutions.
- 70mΩ R<sub>DS(ON)</sub>
   Minimizes the conduction losses through the devices, ideal for high-efficiency power management applications.
- Fast Short-Circuit Response Time
   2µs short-circuit response time provides great protection to both itself and the load from shortcircuit conditions.
- Higher V<sub>IN</sub> and ESD Rating
   6.5V maximum V<sub>IN</sub> and 300V MM ESD rating provides better reliability than competing solutions.





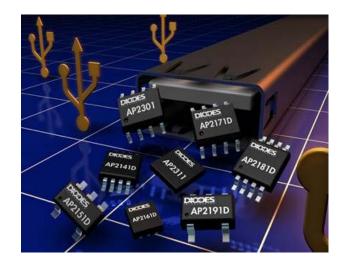
# AP2301 and AP2311

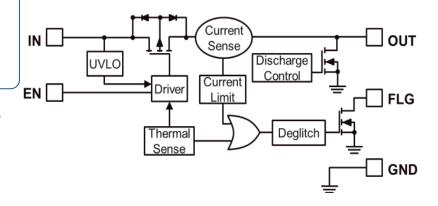
## 2.0A Single Channel, Current-Limited Power Switch

#### The Diodes Advantage

- Low Thermal Resistance
   The exposed pad SO-8EP/MSOP-8EP packages provide lower junction temperature and more reliable solutions.
- 70mΩ R<sub>DS(ON)</sub>
   Minimizes the conduction losses through the devices, ideal for high-efficiency power management applications
- Fast Short-Circuit Response Time
   2µs short-circuit response time provides great protection to both itself and the load from shortcircuit conditions.
- Higher V<sub>IN</sub> and ESD Rating
   6.5V maximum V<sub>IN</sub> and 300V MM ESD rating provides better reliability than competing solutions.

AP2401/11 offer same performance as AP2301/11 with Latch-off under OCP conditions





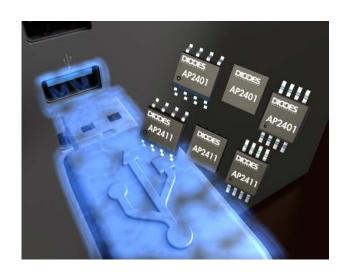
## AP2401 and AP2411

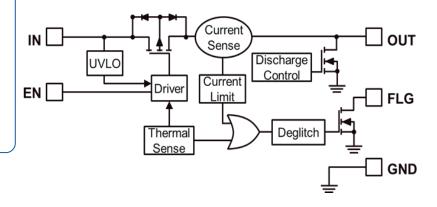
# 2.0A Single Channel Current-Limited Power Switch with Latch-Off

#### The Diodes Advantage

- Latch-Off when OCP Triggered
   Latch-Off mode provides better protection to both
   the power source and the end equipment.
- 70mΩ R<sub>DS(ON)</sub>
   Minimizes the conduction losses through the devices, ideal for high-efficiency power management applications.
- Fast Short-Circuit Response Time
   2µs short-circuit response time provides great protection to both itself and the load from shortcircuit conditions.
- Higher V<sub>IN</sub> and ESD Rating
   6.5V maximum V<sub>IN</sub> and 300V MM ESD rating provides better reliability than competing solutions.

AP2301/11 offer same performance as AP2401/11 without Latch-off under OCP conditions





## Single Channel USB switches Micrel + Diodes Pin out

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Part Number	Max Cont. Output Current	Maximum Current Limit	Enable Logic (Active)	Min Operating Voltage	Max Operating Voltage	Quiescent Current	$R_{DS(ON)}$ $(V_{IN} = 5V)$	Output Discharge	OCP Output Latch Off	OCP Flag	Ambient Temp Range	Pin out	Package Outlines
	Α	Α		V	V	μΑ	mΩ		O		°C		
AP2331	0.2	0.5		2.7	5.5	65	110	Υ			-40 to +85	Diodes	SOT23
AP2337	1	1.9		2.7	5.5	65	110	Υ			-40 to +85	Diodes	SOT23
AP2145	0.5	1	High	2.7	5.5	45	90	Υ		Υ	-40 to +85	Micrel	MSOP-8EP,
AP2155	0.5	1	High	2.7	5.5	45	90	Υ		Υ	-40 to +85	iviiciei	SO-8



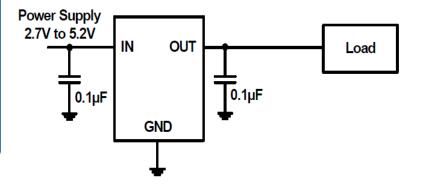


# **AP2331**

0.2A Single Channel HDMI Current-Limited Power Switch

- Reverse-current blocking when V<sub>IN</sub> = 0V
   Avoids leakage current from OUT to IN.
- Built-in 0.7ms Soft-start
   Reduces in-rush currents → improves system robustness.
- Reverse current limit, UVLO, over-current, output over-voltage, over-temperature and short-circuit protection
   Improve robustness of HDMI ports.
- Output discharge function
   Controlled discharge of output capacitor when power removed.





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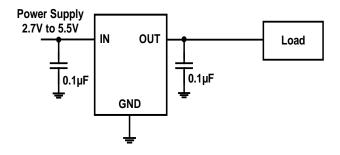
## 1A SOT23 Single Channel Current-Limited Load Switch

#### The Diodes Advantage

The AP2337 provides fast and accurate over-current protection for cost effective USB port protection

- 110mΩ R<sub>DSON</sub> for 1A continuous load in SOT23
   Cost effective USB protection for applications that do not need Enable and Fault reporting and improved performance than traditional PolyFuse.
- Fast short circuit response time: 5µs
   Prevents false system shutdown/restart → improve system robustness.
- Output discharge function
   Controlled discharge of output capacitor when disabled.
- Reverse current blocking, UVLO, over-current, output over-voltage, over-temperature and short-circuit protection
   Improve robustness of USB ports.





# **Dual Channel USB Switches**

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	Part Number	Max. Cont. Output Current	Max. Current Limit	Enable Logic (Active)	Minimum  < Operating Voltage	Maximum < Operating Voltaαe		$ \begin{array}{ll} R_{\text{DS}(\text{ON})} \\ \text{(V_{IN} = 5V)} \end{array} $	Output Discharge	OCP Output Latch Off	OCP Flag	Operating ဂို Ambient Temp Range	Pin out	Package Outlines	
	AP2142	A 0.5	1	Low	2.7	5.5	μA 100	mΩ 115			Υ	-40 to +85	ΤI	MSOP-8EP, SO-	
	AP2152	0.5	1	High	2.7	5.5	100	115			Υ	-40 to +85	TI	8	
	AP2142 A	0.5	1	Low	2.7	5.5	115	85	Υ		Υ	-40 to +85	TI	MSOP-8EP, SO-	
	AP2152 A	0.5	1	High	2.7	5.5	115	85	Υ		Υ	-40 to +85	TI	8 U-DFN3030-8	
	AP2146	0.5	1	Low	2.7	5.5	95	90			Υ	-40 to +85	Micrel	MSOP-8EP, SO-	
	AP2156	0.5	1	High	2.7	5.5	95	90			Υ	-40 to +85	Micrel	8	
	AP2162	1	1.9	Low	2.7	5.5	100	115			Υ	-40 to +85	TI	MSOP-8EP, SO-	
	AP2172	1	1.9	High	2.7	5.5	100	115			Υ	-40 to +85	TI	8	
	AP2172 A	1	1.7	High	2.7	5.5	115	85	Υ		Υ	-40 to +85	TI	MSOP-8EP, SO-	
	AP2162 A	1	1.7	Low	2.7	5.5	115	85	Υ		Υ	-40 to +85	TI	8, U-DFN3030-8	
1	AP2166	1	1.9	Low	2.7	5.5	95	90			Υ	-40 - +85	Micrel	MSOP-8EP, SO-	u
•	AP2176	1	1.9	High	2.7	5.5	95	90			Υ	-40 to +85	Micrel	8	
					I							-40 to			1

# 2A USB Power Switch Cross Reference

PARAMETER	AP2301MP G	AP2101MP G	G547E1	RT9715FG	TPS2000 C
Maximum V <sub>in</sub>	6.5V	6.5V	6V	6V	6V
Recommend V <sub>in</sub> Range	2.7V~5.5V	2.7V~5.5V	2.7V~5.5V	2.7V~5.5V	4.5V~5.5V
Maximum Input Voltage	6.5V	6.5V	6V	6V	6V
$T_JMAX$	150°C	150°C	150°C	150°C	125°C
Thermal Shutdown Limit	140°C	140°C	135°C	120°C	135°C
Thermal Hysteresis	20°C	20°C	20°C	20°C	20°C
ESD HBM	2kV	4kV	2kV	2kV	2kV
ESD MM	300V	300V	N/A	200V	CDM 500V
I <sub>lim</sub> (min/typ/max)	2.0/2.5/2.85 A	2.1/2.45/2.8 A	2.1/2.5/3.3 A	2/2.5/3.2A	2.87A (typ)
I <sub>short</sub> lim (typ)	2.75A	2.5A	1.7A	1.7A	2.87A
R <sub>dson</sub> (typ/max)	$70/84m\Omega$	$90/115m\Omega$	$90/110m\Omega$	$90/110m\Omega$	$90/110 m\Omega$
V <sub>UVLO</sub> (min/typ/max)	1.6/2/2.4V	1.6/1.9/2.5V	2.2/2.5/2.7 V	1.3/1.7/NA V	3V/NA/4V
I <sub>Q</sub> max	100μΑ	70µA	N/A	70μΑ	90µA
I <sub>LEAKAGE</sub> max	1µA	1µA	1µA	1µA	1μΑ

# 2.5A USB Power Switch Cross Reference

PARAMETER	AP2501/11	G547N1/N2	RT9703FG	TPS2554/5
Maximum V <sub>in</sub>	6.5V	6V	6.5V	7V
Recommend V <sub>in</sub> Range	2.7V~5.5V	2.7V~5.5V	2V~5.5V	4.5V~5.5V
$T_{JMAX}$	150°C	150°C	125°C	125°C
Thermal Shutdown Limit	140°C	135°C	130°C	135°C
Thermal Hysteresis	20°C	20°C	10°C	10°C
ESD HBM	2kV	2kV	8kV	2kV
ESD MM	300V	N/A	800V	CDM 500V
I <sub>lim</sub> (min/typ/max)	2.8/3.7/4.5A	2.8/3.7/5A	-/3.5/- A	2.55/2.84/3.1A
I <sub>short</sub> lim (typ)	3.7A	1.7A	Adjustable	Adjustable
R <sub>dson</sub> (typ/max)	$70/84m\Omega$	$70/78m\Omega$	$80/100 m\Omega$	$73/120m\Omega$
V <sub>UVLO</sub> (min/typ/max)	1.6/2/2.4V	2.2/2.5/2.7V	1.3/1.7/NA V	3.9/4.1/4.3V
I <sub>Q</sub> max	100µA	135µA	50μΑ	90μΑ
I <sub>LEAKAGE</sub> max	1µA	1µA	1µA	1µA
Packages	MSOP-8/EP SO-8 DFN3030-8	MSOP-8EP SO-8 TDFN3x3-8	SO-8	DFN3030-10

# AP2552/3 USB Power Switch Cross Reference

PAI	RAMETER		AP2552/3/2A/3A	TPS2552/3/2-1/3-1	MIC2009
Maximum V <sub>IN</sub>	l	Abs	6.5V	7V	6V
$T_{JMAX}$		Max	150°C	125°C	150
Max continuo	ous I <sub>OUT</sub>	Ratings	Internally limited	Internally limited	2.25A
ESD HBM			2kV	2kV	2kV
ESD MM	ESD MM		300V	CDM 500V	200V
Recommend	V <sub>IN</sub> Range		2.7V~5.5V	4.5V~5.5V	2.5~5.5V
Adjustable C	urrent Limit	range	0.075~2.3A	0.075~1.7A	0.2~2A
R <sub>DSON</sub> (typ/m	ax) (@5V)		$70/84m\Omega$	$73/120m\Omega$	$70/100~\text{m}\Omega$
V <sub>UVLO</sub> (min/ty	p/max)		1.6 / 2 / 2.4V 3.9 / 4.1 / 4.3V		2 / 2.25 / 2.5V
I <sub>Q</sub> max			100μΑ	90µA	330µA
I <sub>LEAKAGE</sub> max			1µA	1µA	100µA
I <sub>LIM</sub> (min/typ/r	max)		6% tol at 1.5A	6%	Not specified
I <sub>SC</sub> (typ)			3.7A	0 /0	Not Specified
During over	output late	ches off	AP255xA	TPS255x-1	
current,	During over-		AP255x	TPS255x	MIC2009
Thermal Shutdown Limit		t	140°C	135°C	145°C
Thermal Hysteresis		20°C	10°C	10°C	
Packages			DFN2020C-6, SOT26	DFN2020-6, SOT26	DFN2020-6, SOT26

# Single-Channel USB PW SW Competitive Cross Reference

DIODES Inc. Part Number	Cont. Curren t	Current Limit	Package	En	TI Part Number	GMT Part Number	RichTek Part Number
AP2141WG			SOT-25	Low	TPS2041BDBV	G5240D2T1U	RT9711DPBG
AP2151WG			501-25	High	TPS2051BDBV	G5240D1T1U	RT9711CPBG
AP2141SG	0.5A	0.8A	SO-8	Low	TPS2041BD	G545D2P1U	RT9711DPS
AP2151SG	0.5A	U.OA	30-6	High	TPS2051BD	G545D1P1U	RT9711CPS
AP2141MPG			MSOP-8EP	Low	TPS2041BDGN	G545D2P8U	RT9711DPF
AP2151MPG			WISOF-6LF	High	TPS2051BDGN	G545D1P8U	RT9711CPF
AP2161WG			SOT-25	Low	TPS2061BDBV	G5240B2T1U	RT9715FGBG
AP2171WG			JO1-23	High	TPS2065BDBV	G5240B1T1U	RT9715EGBG
AP2161SG	1A	1.5A	SO-8	Low	TPS2061BD	G545B2P1U	RT9715FGS
AP2171SG	1/1		30-6	High	TPS2065BD	G545B1P1U	RT9715EGS
AP2161MPG			MSOP-8EP	Low	TPS2061BDGN	G545B2P8U	RT9715FGF
AP2171MPG				High	TPS2065BDGN	G545B1P8U	RT9715EGF
AP2181WG			SOT-25	Low	TPS2068DBV	G5240A2T1U	RT9711BGBG/ RT9715DGBG
AP2191WG			301-23	High	TPS2069DBV	G5240A1T1U	RT9711AGBG/ RT9715CGBG
AP2181SG	1.5A	2.1A	SO-8	Low	TPS2068D	G545A2P1U	RT9711BPS/ RT9715DGS
AP2191SG	1.5A	2.1A	30-6	High	TPS2069D	G545A1P1U	RT9711APS/ RT9715CGS
AP2181AMPG			MSOP-8EP	Low	TPS2068DGN	G545A2P8U	RT9711BPF/ RT9715DGF
AP2191AMPG			IVISOP-8EP	High	TPS2069DGN	G545A1P8U	RT9711APF/ RT9715CGF

DIODES Inc. Part Number	Cont. Current	Current Limit	Package	En	TI Part Number	GMT Part Number
AP2142SG		0.8A	SOP-8L	Low	TPS2042BD	G546D2P1UF
AP2142MPG	0.5A		MSOP-8L-EP		TPS2042BDGN	G546D2P81U
AP2152SG	each Ch.		SOP-8L	High	TPS2052BD	G546D1P1UF
AP2152MPG			MSOP-8L-EP		TPS2052BDGN	G546D1P81U
AP2162SG		1.5A	SOP-8L	Low	TPS2062D	G546B2P1UF
AP2162MPG	1.0A		MSOP-8L-EP		TPS2062DGN	G546B2P81U
AP2172SG	each Ch.		SOP-8L	High	TPS2066D	G546B1P1UF
AP2172MPG			MSOP-8L-EP		TPS2066DGN	G546B1P81U
AP2182SG		2.1A	SOP-8L	Low		G546A2P1UF
AP2182MPG	1.5A Each		MSOP-8L-EP		TPS2060DGN	G546A2P81U
AP2192SG	Ch.		SOP-8L	High		G546A1P1UF
AP2192MPG			MSOP-8L-EP		TPS2064DGN	G546A1P81U

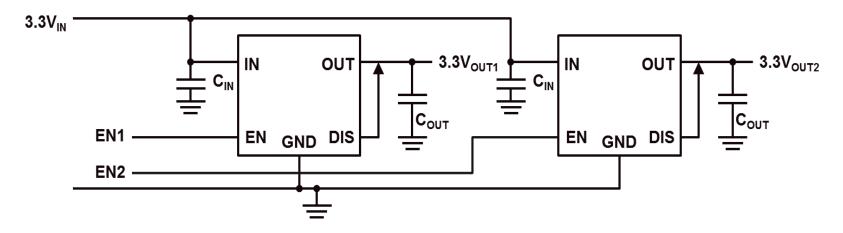




## Single-Channel 2A USB Power Switch Competitive Cross Reference

DIODES Inc. Part Number	Cont. Curren t	Curren t Limit	Package	En	TI Part Number	GMT Part Number	RichTek Part Number
AP2101SG/ AP2301SG		0.54	SO-8	Low	TPS2024D	G547E2P11U	RT9715BS
AP2111SG/ AP2311SG	2.4			High	TPS2034D	G547E1P11U	RT9715AS
AP2101MPG/ AP2301MPG	2A	2.5A	MSOP-8EP	Low		G547I2P81U	RT9715BF
AP2111MPG/ AP2311MPG				High		G547I1P81U	RT9715AF

Part Number	Min. Input Voltage	Max. Input Voltage	Maximum Output Current	nable Logic (Active)	Typical Quiescent Current	RDS(ON)	Operating Ambient Temperature Ranαe	Output Turn-On Rise Time	Output Turn-On Delav Time	Output Discharge	Package Outlines
	V	V	Α	Ш	μΑ	mΩ	°C	μs	μs		
AP2280-1	1.5	6	2	Liah	0.004	80	-40 to	100	1	\ \	SOT25, U-DFN2018-
AP2280-2	1.5	0	_	High	0.004   80	+85	1000	'	Ĭ	6	
AP2281-1	1.5	6	2	High	0.01	80	-40 to	1000	1	N	SOT26, U-DFN2018-
AP2281-3	1.5	O		High	0.01	00	+85	100		Υ	6



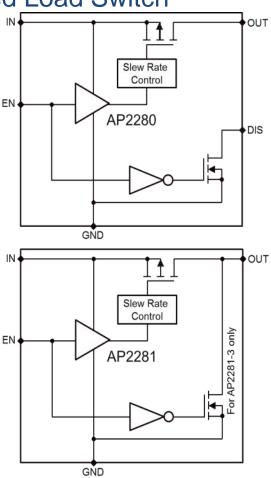


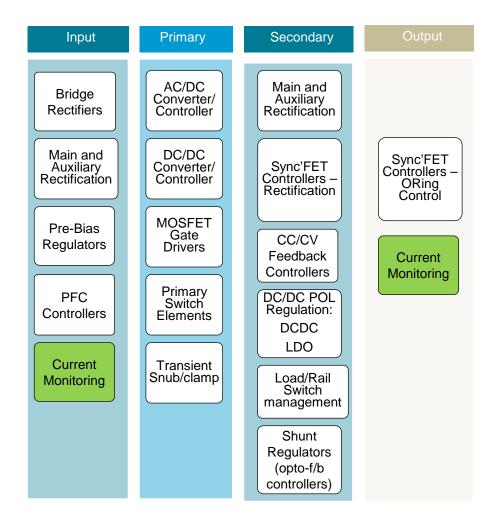


# AP2280/1

80mΩ Single Channel Slew Rate Controlled Load Switch

- Wide Input Voltage Range (1.5V to 6.0V)
   Simple power distribution system solution for 5V,
   3.3V and core voltage supplies
- Controlled Turn-on Slew rate and rise times 100µs: AP2280-1, AP2281-3 1000µs: AP2280-2, AP2281-1 Reduces in-rush currents → improves system robustness.
- Low 80mΩ Pass PMOS R<sub>DS(ON)</sub>
   Reduces in-line voltage drop.
- Output discharge function (AP2280 & AP2281-3)
   Controlled discharge of output capacitor when output disabled.







## **High-side current monitors**

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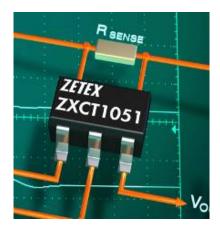
The ZXCT range of high-side current monitors and current sense amplifiers provides elegant design solutions for current measurement and power control.

#### Key features:

- Low and high-side current sensing
- Output voltage scaling
- Up to 2.5V sense voltage
- 2.2V 20V supply range
- 1% typical accuracy ZXCT series

#### Innovation achievements:

- Simplest, lowest Iq gas gauge Battery powered products
- Simplest, short circuit detector DC-DC converter and high-side load
- 3-pin sensing with low-side output DC-DC bricks, high-side load, etc

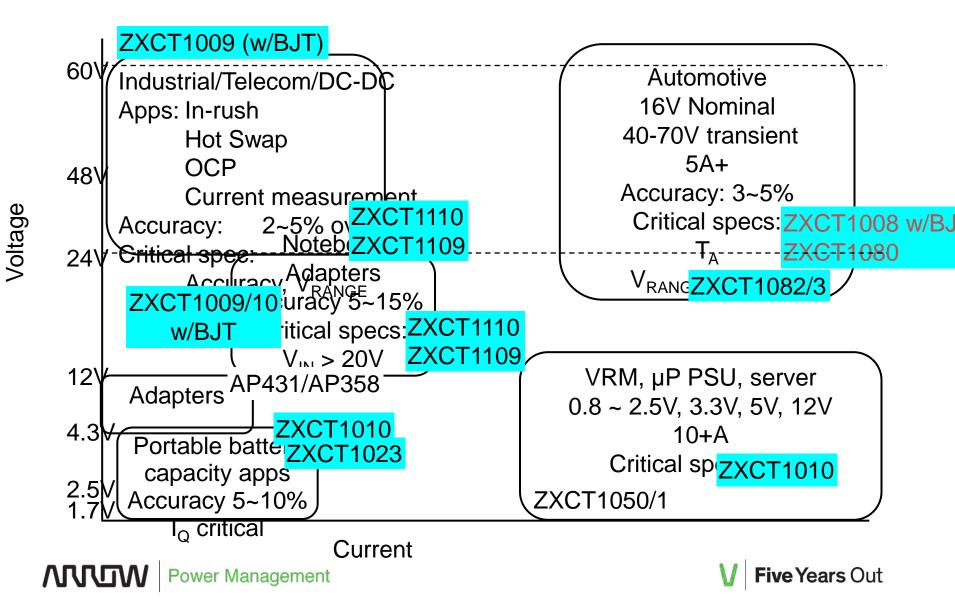


#### Key applications:

- Battery chargers
- Smart battery packs
- DC motor control
- Over current monitor
- Power management
- Hot swap inrush current limit

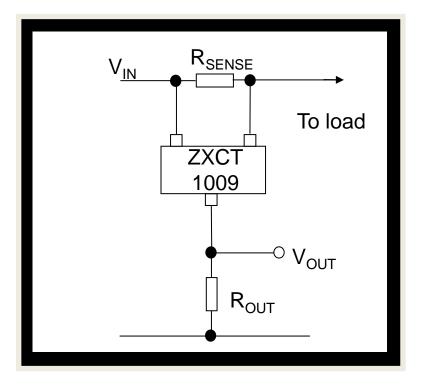






## ZXCT1009 - 'Simplest Current

- 3 Pin Device in SOT23
  - SENSE+ pin
  - SENSE- pin
  - OUT pin
- R<sub>SENSE</sub> in series with supply
- Choosing R<sub>SENSE</sub> compromise
  - Small to minimise power loss
  - Large enough so that I<sub>LOAD(MIN)</sub> V<sub>SENSE</sub> > 10mV
  - Quiescent current flows through R<sub>OUT</sub>
  - $V_{OS} = 0.4 \text{mV} @ R_{OUT} = 100 \Omega$



Value proposition in High-side current sensing: "3-pin sensing with low-side output"

in DC-DC bricks, High- side loads (motor, lamps, relays), power supply rails....

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- Threshold current monitoring (min and/or max)
- Short-circuit current monitoring
- Constant current loop control without disturbing ground plane (or when there's no easy access to the ground return
- Electronic fuse functions total disconnect, with auto reattempt
- Cycle by cycle current monitoring
- Power budgeting control
- Gas gauging



### **ZXCT1051** for Short Circuit Protection

74

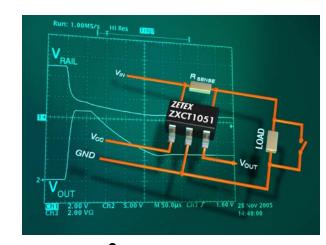
 Current monitor provides over current Protection

Separate power supply from auxiliary

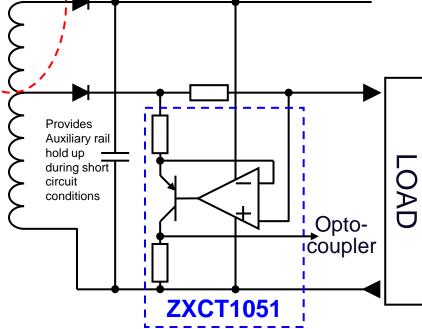
winding enables short-circuit opération

Doesn't upset ground plane winding unlike conventional op amp solution

- Hold-up capacitor keeps up V<sub>CC</sub> rail
- Gives system time to respond to fault

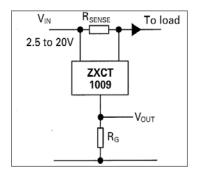


Five Years Out

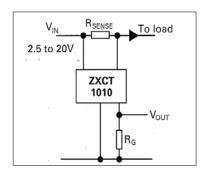


### Current Monitors – Current Output

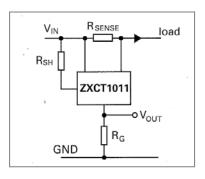
#### The ZXCT Series Variations:



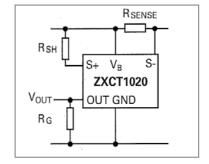
Simplest Current Monitor – Output current proportional to the sense Voltage. Only 2 external components, 4uA lq.



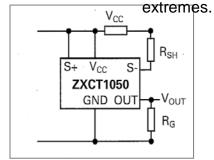
Improved Current Offset – Separate ground pin avoids circuit current flowing through output resistor.



Improved Temperature Drift— External resistor to determine transconductance results in lower temperature coefficient and gives better accuracy at temperature



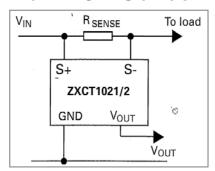
Low Offset at Low Vsence—External resistor to set transconductance and allows its offset to be trimmed. Improved accuracy over ZXCT1010.



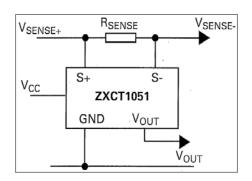
Wide Common-Mode Range— External resistor to set transconductance and another sets the gain. Offset is trimmed improving accuracy at small sense voltages.

### Current Monitors – Voltage Output

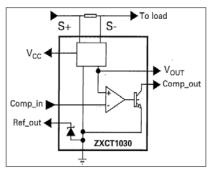
#### The ZXCT Series Variations:



# Highest Accuracy at Low Vsence – Fixed gain scaling of 10 or 100 allows low value sense resistor, thus reducing power dissipation and voltage drop.



#### Wide Common-Mode Input Range -Designed to measure at voltages ranging from under supply to ground. Suitable for systems which need to function under short circuit conditions.



# Internal Reference and Comparator — Fixed gain scaling of 10, with non-latching output comparator and 1.24V Vref to enable more integrated solutions. Separate

enable more integrated solutions. Separate Vcc ensures operation under short circuit conditions.

V<sub>SENSE+</sub>

R<sub>SENSE</sub>

V<sub>SENSE-</sub>

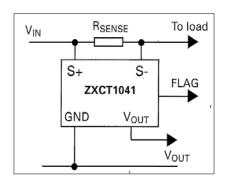
V<sub>SENSE-</sub>

V<sub>SENSE-</sub>

V<sub>OUT</sub>

V<sub>OUT</sub>

Large Common-Mode Range— Wide continuous common-mode input range to 60V. Separate power supply pin provides power to an internal buffer lowering the output impedance.



#### Bi-directional Voltage w/ direction

Flag – Vout pin is analog and internally scaled to 10x Vsense. Flag is an open collector output that can be coupled to logic level voltages. Applications include gas-gauging.

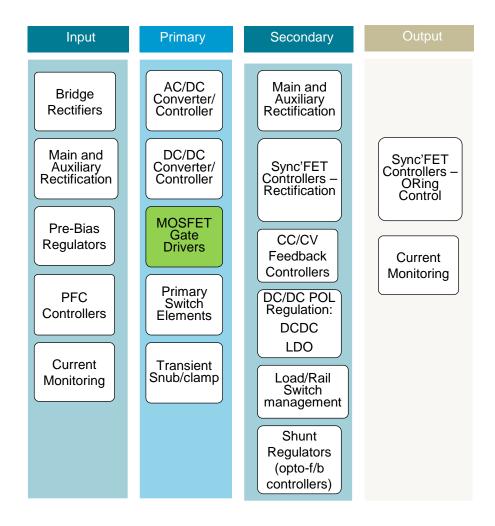
RSENSE

8

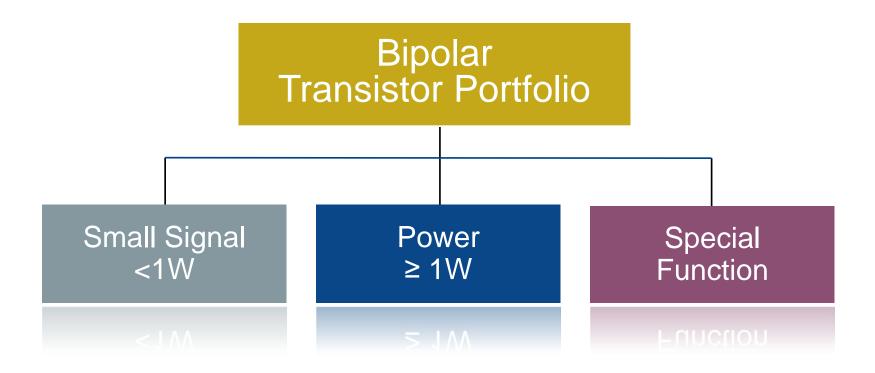
1N+
INISET

SOUTH OF THE SET OF

# High Inrush and Current Limit Controller – Provides in-rush current limiting and over current protection functions when used with an external PMOS, behaves as an electronic fuse.



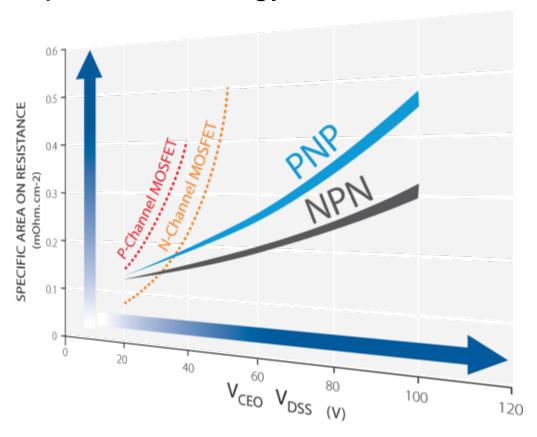




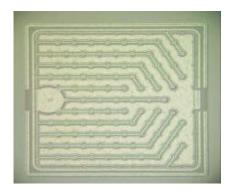




### Bipolar Technology

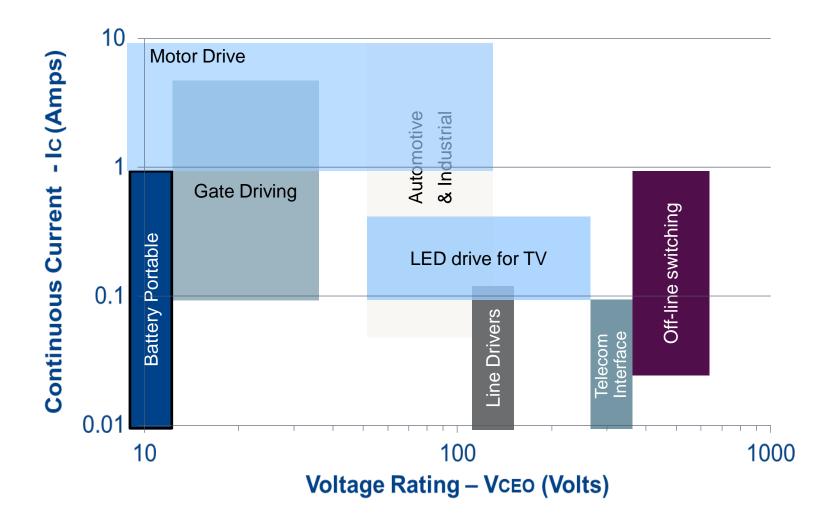


## World leading Bipolar processing and designs



- Inventor of the Matrix emitter transistor structure.
- Industry leading low saturation voltage.
- Highest current handling capability for given package outlines.
- Reduced switching losses due to smaller die sizes.
- High minimum gains to reduce base drive requirements.
- Reverse blocking capability.









#### Diodes PowerDI \*5 Advantage

Reduced footprint on PCB

43% smaller than SOT223; 60% smaller than DPAK (TO252)

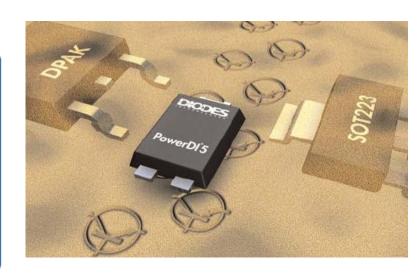
Low profile package Ideal for use in height restricted designs

Excellent thermal performance

Can replace SOT223 in applications dependant on the thermal performance of the package

Minimum copper power rating of 0.74W

Excellent thermal performance from small area giving improved power density



Device		V <sub>CEO</sub>	lc	I <sub>CM</sub>	P <sub>D</sub>	h <sub>FE</sub>	@ lc	V <sub>CE(sat)</sub>	@ lc/l <sub>B</sub>	f <sub>T</sub>	
Туре	Part No	V	Α	Α	W	min	A	Max mV	A / mA	MHz	Application
	DXT690BP5	45	3	6	3.2	400	2	360	1/5	150	LED drive, Motor Drive
	DXT2010P5	60	6	30	3.2	100	2	70	1 / 50	130	Motor Drive, Regular circuit
NPN	DXTN07100BP5	100	2	6	3.2	25	2	300	1 / 100	140	Regular circuit
INFIN	DXT2011P5	100	6	10	3.2	100	2	65	1 / 100	130	Motor Drive, Regular circuit
	DXT5551P5	160	0.6	-	2.25	30	0.05	200	0.05/5	130	Telecom line driver
	DXT458P5	400	0.3	1	2.8	100	0.05	200	0.05/6	50	PSU start up, Telecom switch
	DXTP19020DP5	-20	-8	-15	3.2	200	-2	-130	-1 / -10	176	Load switch, Battery charging
	DXT790AP5	<del>-4</del> 0	-3	-6	3.2	200	-1	-350	-1 / -10	100	Load Switch, Motor Drive
PNP	DXT2012P5	-60	-5.5	-15	3.2	100	-2	-70	-1 / -100	120	Motor Drive, Regular circuit
FINE	DXT2013P5	-100	-5	-10	3.2	100	-1	-90	-1 / -100	125	SLIC DC-DC converter
	DXT2014P5	-140	-4	-10	3.2	100	-1	-120	-1 / -100	120	SLIC DC-DC converter
	DXTP03200BP5	-200	-2	-5	3.2	100	-1	-160	-1 / -100	105	SLIC DC-DC converter

### The Diodes' Advantage

Ultra-Miniature Package1.4mm x 1.1mm footprint; 78% smaller than SOT23

■ Excellent thermal performance FR-4 PCB power rating of 0.38W on minimum copper foot print

Very low saturation voltage
 Low voltage drop, reduced dissipation and heating.

Good gain hold up
 Low drive requirements for pulse applications

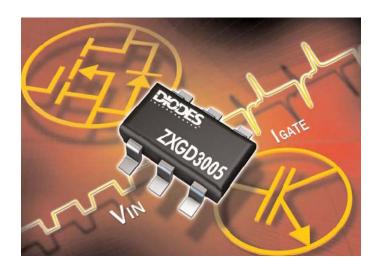


		V <sub>ceo</sub> I <sub>c</sub>			P <sub>D</sub>		h,	E			V <sub>CE (S</sub>	AT)		fτ	R <sub>ce(SAT)</sub>
Part Number	Device Type	CEO	'c	'см		Min	@l <sub>c</sub>	Min	@l <sub>c</sub>	Max.	@ I <sub>c</sub> /I <sub>B</sub>	Max	@ I <sub>c</sub> /I <sub>B</sub>	МН	
		V	Α	A	W		Α		Α	mV	A/mA	mV	A/mA	z	mΩ
ZXTN26020DMF	NPN	20	1.5	4	0.38	300	0.1	200	2	45	0.1/1	225	2/100	260	90
ZXTP26020DMF	PNP	-20	-1.25	-4	0.38	300	-0.1	175	-1	-80	-0.1/-1	-155	-1/-50	200	125

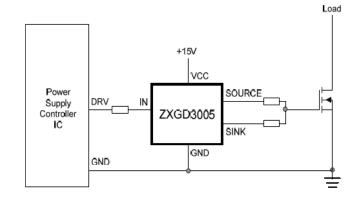
#### The Diodes' Advantage

ZXGD3005E6 10 Amp Gate Driver is designed to ensure the ultra-fast switching of MOSFETs and IGBTs.

- Emitter-follower configuration
   High-speed non-inverting gate driver that can deliver very short propagation delay times of less than 10ns along with rise/fall times of less than 20ns.
- 4A output with 1mA input The ZXGD3005E6 output can source/sink 4A with only 1mA on the input, enabling it to buffer the high output impedance of a controller IC to the effectively low impedance of MOSFET or IGBT gate during switching.
- Wide operating voltage
   Up to 25V allows full enhancement to minimize on-state losses and permits +15V to
   -5V gate drive to be applied to prevent dV/dt induced false triggering of IGBTs.
- Resistant to latch-up and shoot-through issues The rugged design makes the ZXGD3005E6 inherently resistant to latch-up and shoot-through issues.
- Optimized pin-out
   In a space-saving low profile SOT26 package, the pin-out has been designed to simplify PCB layout and reduce parasitic trace inductances.
- AEC-Q101, "Green" and RoHS Compliant The ZXGD3005E6 is qualified to AEC-Q101 standard, are RoHS compliant and has insignificant levels of halogens or antimony compounds.



#### Circuit example of driving a MOSFET



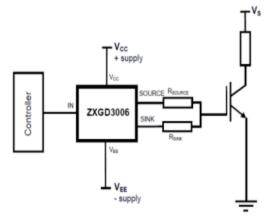
### ZXGD3006E6: 40V Gate Driver

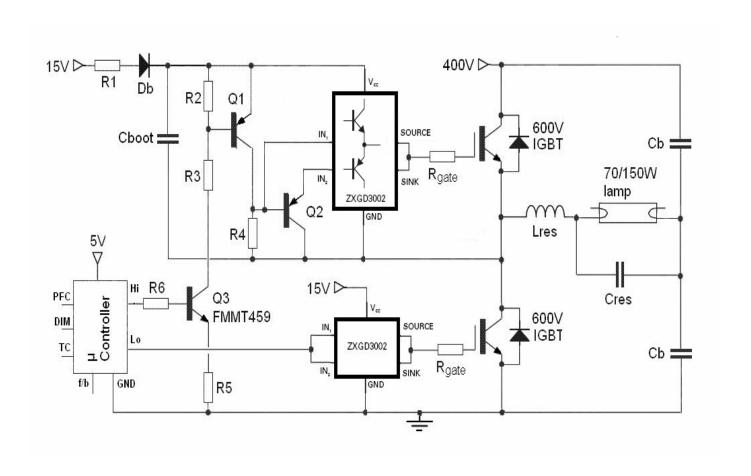
### Advantage

ZXGD3006E6 is a Gate Driver capable of driving 10 Amps into an IGBT gate capacitive load from 40V supply.

- 4A output from 1mA input Typically provides a drive current of 4A for an input of 1mA, making it a perfect high-gain buffer stage between the high output impedance of a controller and the low input impedance of a IGBT.
- 40V wide operating voltage
   Full enhancement to minimize on-state losses and permits
   +20V to -18V gate driving to prevent dV/dt induced false triggering of IGBTs.
- Resistant to latch-up and shoot-through issues Emitter-follower configuration means that the ZXGD3006E6 is inherently resistant to latch-up and shoot-through issues.
- Short propagation delay with controlled rise and fall times Propagation delay <10ns from the emitter-follower configuration can rapidly track input, whilst separate source and sink outputs allow tailored control of the rise and fall charging times to minimize the risk of EMI and cross conduction issues.
- Reduced parasitic trace inductances SOT26 device pin-out has been optimized enabling a simplification of PCB layouts and a reduction in parasitic trace inductances.
- AEC-Q101, "Green" and RoHS Compliant The ZXGD3006E6 is qualified to AEC-Q101 standard, are RoHS compliant and has insignificant levels of halogens or antimony compounds.











### Gate Driving – Target Markets

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#### **Automotive**

- All electric cars for DC-DC conversion
- In-wheel electric drive
- Battery charging
- LED lighting

#### **Motor Drive**

- Gate driving IGBTs in Intelligent Power Modules (IPM)
- Industrial motors in 1, 2 or 3 phase systems
- H-Bridges including full and half

#### **DC-AC Inverters**

Grid power conversion in:

- Solar
- Wind
- Fuel Cell

### WDW

### Power Management

#### **SIC MOSFETs**

- Gate driving SiC MOSFETs
- Emerging new high power switch that can replace IGBTs
- ZXGD3006 is well suited for driving SiC MOSFETs

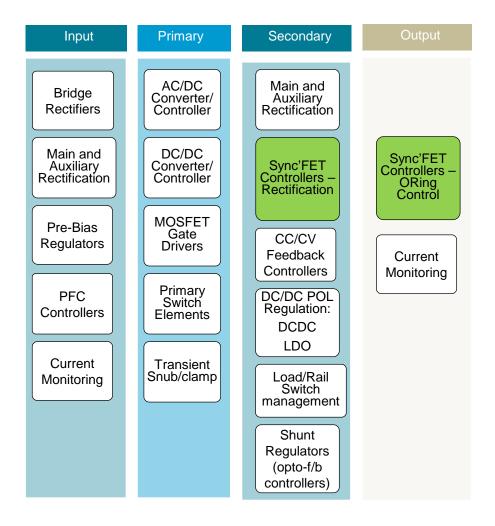
### **Plasma Display Panel**

 Gate driving IGBTs in the Energy Recovery System of Plasma displays

### **Power Supplies**

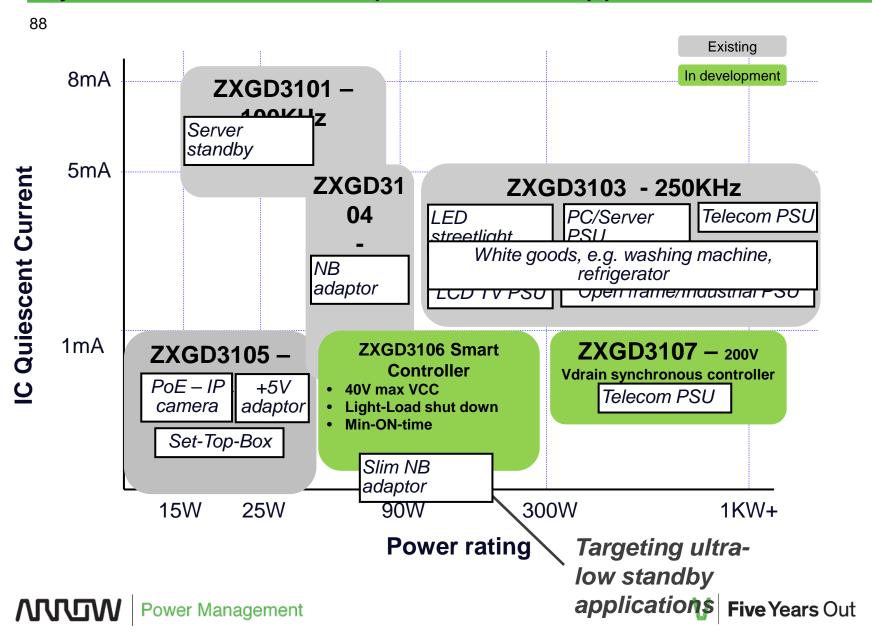
- Gate driving MOSFETs in PFC stage of Switch-Mode (SMPS).
- >500W high efficiency SMPS found in Telecom and Server applications







### Synchronous controller products and applications



## Synchronous controller family

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Parameter	ZXGD3103	ZXGD3104	ZXGD3105	ZXGD3106	ZXGD3107
VCC voltage	5 to 15V	5 to 25V	4.5 to 25V	4.5V to 40V	4.5 to 40V
Quiescent current	5mA	5mA	1mA	370uA sleep	1mA
Drain voltage	180V	180V	100V	200V	200V
Mode of operation	CCM, DCM, QR	CCM, DCM, QR	CCM, DCM, QR	CCM, DCM, QR	CCM, DCM, QR
Max switching Fs	≤250KHz	≤250KHz	≤500KHz	≤500KHz	≤500KHz
'Proportional Gate Drive' control	Yes	Yes	Yes	Yes	Yes
Turn-on delay time	150ns	250ns	70ns	70ns	70ns
Turn-off threshold	-10mV	-10mV	-10mV	-10mV	-10mV
Turn-off delay time	15ns	15ns	15ns	15ns	15ns
Source current	0.25A	0.25A	2A	2A	2A
Sink current	-4A	-4A	-7A	-5A	-5A
Light-load detect	No	No	No	Adjustable	No
Min-ON-time	No	No	No	Adjustable	No
VGS clamp	No	No	No	14.5Vmax	No

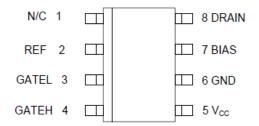




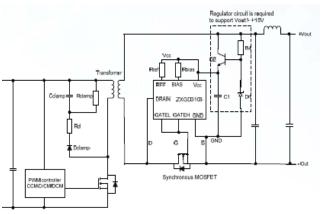
#### The Diodes' Advantage

- Proportional Gate Drive
   Prevents premature turn-off of the synchronous MOSFET giving optimum performance
- Turn-off propagation delay and fall times of 15 and 21ns respectively Prevents reverse conduction and minimises shoot through current ensuring high efficiency operation
- Turn-on propagation delay of 80ns
  Reduces body diode conduction in the synchronous MOSFET, reducing losses.
  Suitable for power supplies switching up to 300kHz
- Operating voltage range 5 to 15V
   Adaptable in various supply configuration
- 180V sensing input

  Permits direct connection to the MOSFET Drain without the need for external protection components







Flyback Converter





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#### **Features**

- Low quiescent current consumption <1.5mA</p>
- ➤ Wide Vcc voltage range 4.5V to 25
- Suitable for driving standard/logic threshold MOSFET
- ➤ High 2A/7A gate source/sink current
- ➤ Fast switching operation < 500KHz
  - Turn-on delay time, t<sub>d</sub> ~ 70ns
  - Turn-on rise time, t<sub>R</sub> ~ 175n
- Optimized MOSFET switch-off to reduce loss
  - Turn-off delay time, t<sub>d</sub> ~ 15n
- ➤ 100V Drain sense voltage capability

#### **Benefits**

- May be biased directly from 5V output power supply
- Low standby power consumption exceeding requirement of Energy Star V2.0
- Minimal component count

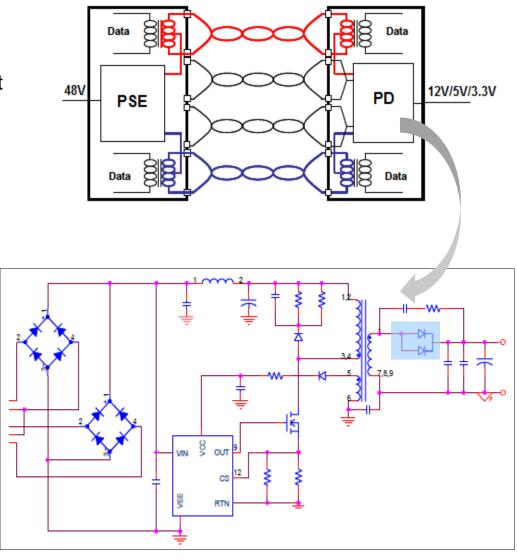
#### **Applications**

- Set-Top-Box power supplies
- PoE Plus Powered Device
- AC/DC 5V adapter/open-frame
- Low voltage rectification circuits



### Application 1: 5V 25W PoE PD power converter

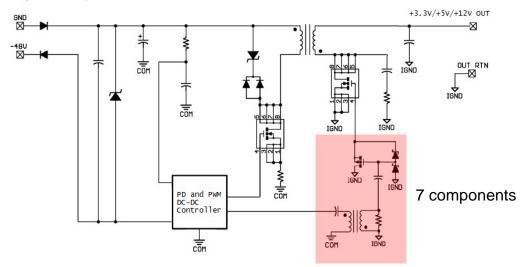
- ➤ IEEE802.3at standard supports power level upto 25.5W in the Powered Device (PD)
- ➤ PD uses Flyback topology to convert 48V PoE input to 5/12V DC output
- ➤ High Flyback conversion efficiency ensures the amount of power that can be delivered to the load meets the IEEE 802.3at standard
- Replacing the Flyback diode with MOSFET increases efficiency
- Applications
  - Security and IP Net cameras
  - VoIP phones
  - Wireless LAN access point
  - PoS terminals



### Synchronous solutions for Powered Device

#### **Current solution**

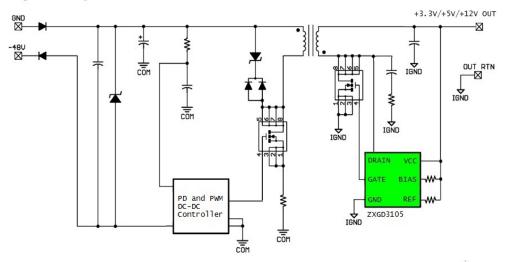
High efficiency POE Powered Device (PD) converter



- ➤ Signal transformer solution
  - Synchronization of primary and secondary-side MOSFETs
  - Requires dedicated primary side
     IC
  - Converter operates in CCM at light load causing sync MOSFET's reverse current conduction and poor efficiency
  - Higher component count and larger solution size

#### **New solution**

High efficiency POE Powered Device (PD) converter



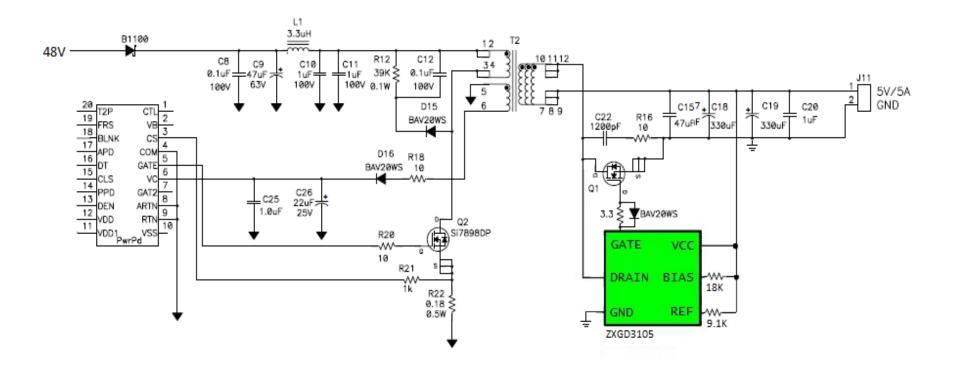
#### > ZXGD3105 solution

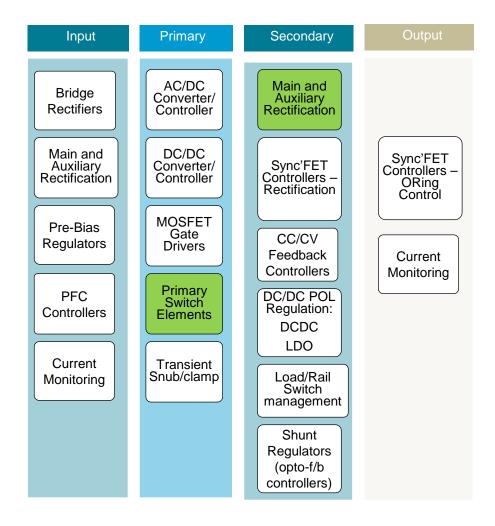
- Low component count
- More cost effective solution
- DCM at light load prevents reverse current conduction through the sync MOSFET
- High conversion efficiency from no load to full load condition

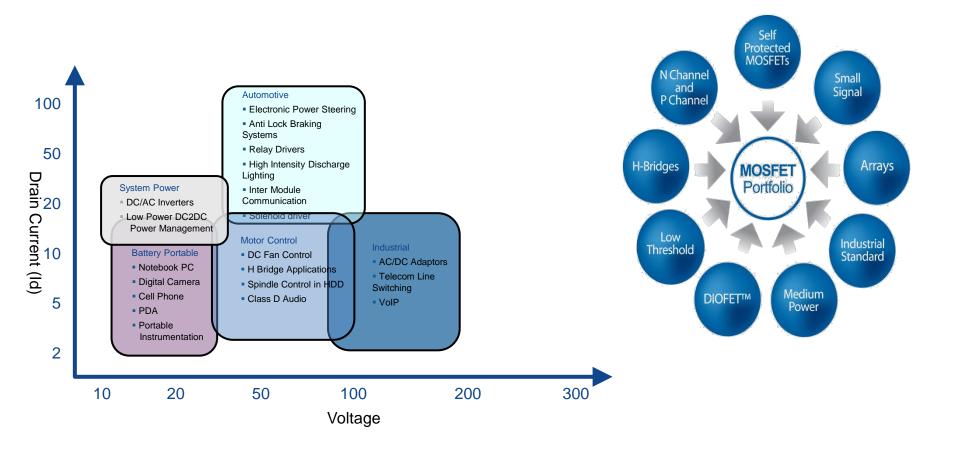
### Synchronous rectification for 5V output 25W PD

### > Specifications

- Input voltage = 48V
- Output voltage/current = 5V/5A
- Switching frequency = 250KHz
- Transformer specification:- Lm = 32µH, Pri:Sec = 1:0.14
- Sync FET Q1 specification:- BVDSS = 40V, R<sub>DS(ON)</sub> @ 5V V<sub>GS</sub>= 3.2mOhm, Qg = 38nC

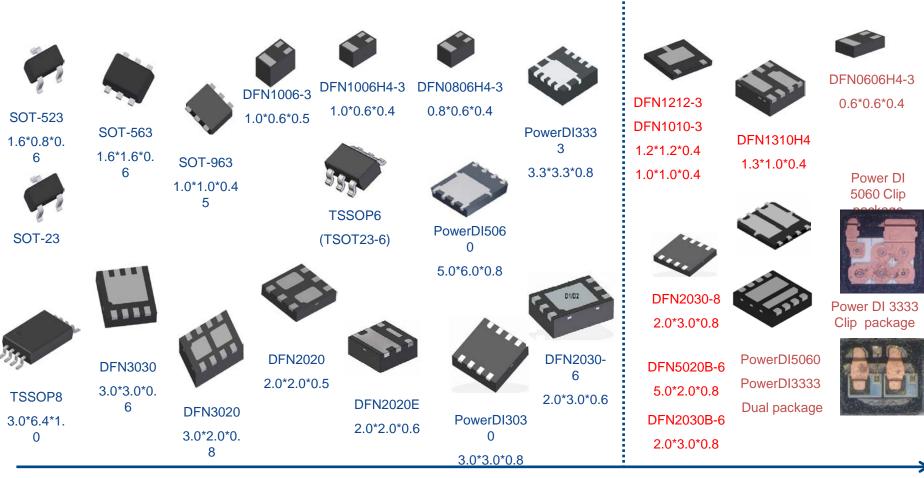












Release 2013 " 2014

Note: Products highlighted in red are not release- contact Diodes for further information

### DFN1006 Portfolio: One of the World's Smallest MOSFETs

#### The Diodes Advantage

#### Small Footprint

The DFN1006-3 occupies 0.6mm² enabling designers to reduce PCB utilized while maintaining performance. The DFN1006-3 provides an equivalent or better performance than SOT723 but occupies only 40% of the PCB area. The DFN1006-3 provides an equivalent performance to many SOT23 yet has a footprint that is 13 times smaller.

#### Low Profile

The DFN1006-3 has an off-board height of 0.4mm (UFB4) or 0.5mm (UFB) making it ideal for thin profile consumer electronic products.

#### Thermally Efficient Package

Low junction to ambient thermal resistance (Rthj-a) support power dissipation up to 1.3W under continuous conditions. Low Rthja enables DFN1006 to replace larger less efficient leaded packages such as SOT723, SOT523, SOT323 whilst maintaining or improving performance.

#### Low R<sub>DSON</sub>

The DMP3010LPS has been designed to withstand the high pulse avalanche energy that can be induced by inductive loads.



Part Number	Part Number Polarity V <sub>DS</sub> V <sub>GS</sub> P <sub>D</sub> @ 25° I <sub>D</sub> @ 25°				I <sub>D</sub> @ 25º	ESD Diode	V <sub>TH</sub> (V)		R <sub>DS(on)</sub>	max Ohms a		Q <sub>g</sub> (nc)Typ.	C <sub>iss</sub> (pF)	
rait Nullibel	Folarity	(V)	(±V)	(W)	(W)	(Y/N)	Min	@10V	@4.5V	@2.5V	@1.8V	@1.5V	@4.5V	Тур.
DMN26D0UFB4	Ν	20	8	0.35		-	0.6		3	4	6	10		17
DMP210DUFB4	Р	-20	8		-	-	-0.5	-	5	7	10	15	-	14
DMN2300UFB4	N	20	8	0.47	1.3	Y	0.5	-	175	220	280	-	1.6	64
DMP21D0UFB	Р	-20	8	0.47	-0.8	-	-0.5	-	400	600	900	-	1.6	64
DMN3730UFB4	N	30	12	0.47	1.03	Y	0.5	-	450	560	730	-	1.6	64
DMN3484UFB4	N	30	12	0.47	-	-	0.5	-	270	400	500	-	2	70
DMP3795UFB4	Р	30	12	0.47	-	-	-0.5	-	460	600	800	-	2	70
DMN62D1SFB4	N	60	20	0.47	-	-	0.8	1850	2100	-	-	-	1.6	64

### PowerDI®5060: DMP3010LPS

#### The Diodes'Advantage

#### Low Thermal Resistance

The PowerDI5060 package has a typical Rthj-c of 2.1°C/W which is 10 times lower than the familiar SO8 package. This superior thermal performance improves power dissipation, reduces MOSFET junction temperature, enabling cooler, more reliable running.

#### Low Profile Package

The PowerDI5060 has a package profile that is <1.1mm making it ideal for thin applications.

#### Low R<sub>DS(ON)</sub>

The low typical  $R_{DS(ON)}$  of the DMP3010LPs ensures that on state losses are kept to a minimum during load switching and battery charging.

#### Avalanche Rated

The DMP3010LPS has been designed to withstand the high pulse avalanche energy

that can be induced by inductive loads.

#### • AECQ101, 'Green' and RoHS Compliant

The DMP3010LPS is qualified to AECQ101 standard and is RoHS compliant.



			V <sub>DS</sub>	V <sub>GS</sub>	ESD Diode	I <sub>D @</sub> 25ºC		nax (mΩ) V <sub>GS</sub>	V <sub>GS(th)</sub>	C <sub>iss</sub> Typ	Q <sub>g</sub> (nC)
Product	Configuration	Туре	(V)	(±V)	(Y/N)	(A)	10V	4.5V	(V)	(pF)	@10V
DMP3010LPS	Single	Р	30	20	N	15	7.5	10	1 .1	6324	126.2

## MOSFET H-Bridges optimize design of DC motor control and inverter circuits

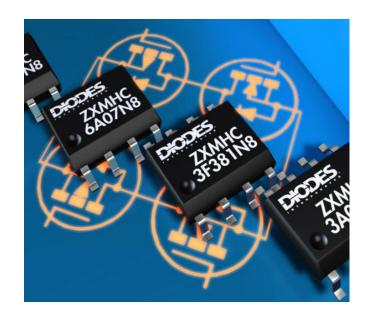
100

### MOSFET H-Bridges

#### The Diodes Advantage

This new MOSFET H-Bridge portfolio can be used to replace 4 single devices (SOT23) or two complementary devices (SO8) in D.C. or motor control and inverter applications. The benefits that this portfolio brings to the end application are:

- Simplify designs
   Qne,MOSFET H-Bridge can replace two dual reducing PCB area footprint by 50%.
- Reduce component count
   One MOSFET H-Bridge can replace two dual SO8's reducing component count and PCB area.
- Reduce inventory cost
   Only one component needs to be stocked instead of







### **MOSFETs**

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#### Requirement

600V MOSFET to address low end performance/commodity market

#### Status

Initial release product – BSS127 – targeted at PSU start up circuits.

Development progressing, further products released Q1, Q2 2012

#### Competitive Position

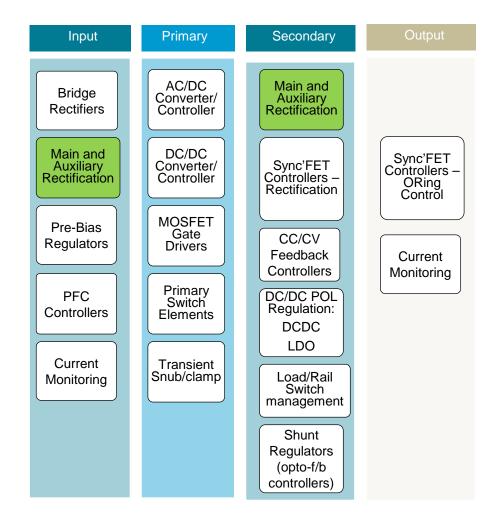
Market entry strategy – targeted at low performance, commodity market.

- Main competitors are AOS, Taiwan Semi
- Not targeted or competitive with Infineon/ST.

Data			imber Configuration ESD		V <sub>GS</sub>	I <sub>DS</sub> 25°C	P <sub>D</sub> 25°C	R <sub>DS(on</sub>	) Max (mΩ)	@ V <sub>GS</sub>	V <sub>GS(th)</sub>	C <sub>ISS</sub> typ.	Qg typ. (nC)	Package Outlines
Sheet			Diodes	V	±V	Α	W	10V	4.5V	2.5V	V	pF	V <sub>GS</sub> =10V	Outlines
T .	V .	¥	₹ 🚜	T &	τ	₹ 🙀	₹ .	T .	T a	T	T	T A	T	T 6
7	ALL	ALL	ALL	from 600 till 650	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL	ALL
N	BSS127S	Single	N	600	20	0.07	0.61	16000	19000	-	4.5	21.8	1.08	SOT23
办	BSS127SSN	Single	N	600	20	0.07	0.61	16000	19000	-	4.5	21.8	1.08	SC59
Żł.	DMG4N65CT	Single	N	650	30	4	2.19	3000	-	-	5	900	13.5	TO220-3
2	DMG9N65CT	Single	N	650	30	9	2.29	1300	-	-	5	2310	39	TO220AB

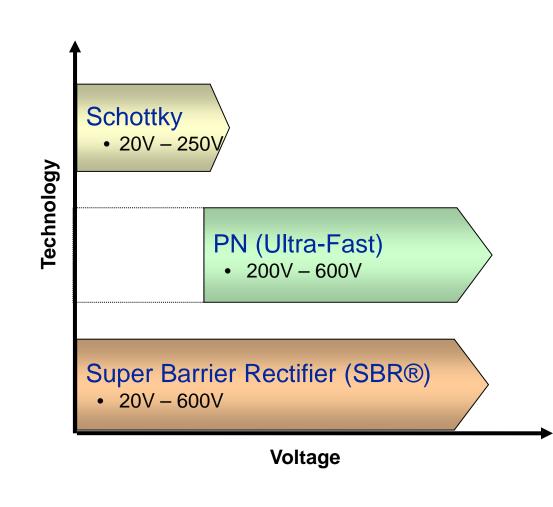
### Power Management - Generalized Block Diagram

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### Scalability of SBR® Technology

- SBR® is the only technology that can be scaled from 20V to 600V without any loss in performance
- Technology can be scaled by current from 0.1A to 60A without loss in performance
- One simple solution to cover all range of voltage application requirements
- High voltage SBR® (>200V)
  has significantly lower V<sub>E</sub> and
  faster switching speed (T<sub>RR</sub>)
  than Ultra-Fast PN junction
  diodes





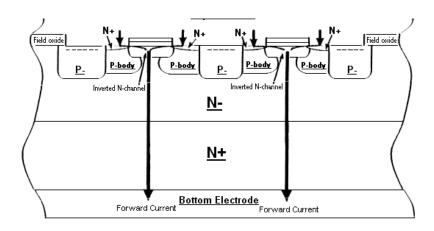


### Super Barrier Rectifier - Device Structure and Operation

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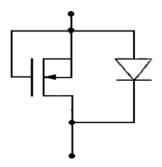
#### **Device Structure Operation of SBR®**

- Traditional (two terminal) device by biasing the gate and source,  $V_{(GS)} \approx 0$
- In forward mode, device operates as majority carrier (MOS) with low V<sub>F</sub> and fast switching
- In reverse mode, electrostatic behavior causes depletion mode, substantially reducing leakage current
- Cellular design operates as thousands of individual units working in parallel

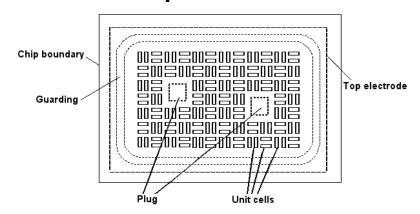


**Diodes Confidential & Proprietary** 





### SBR® (Super Barrier Rectifier) Equivalent Circuit



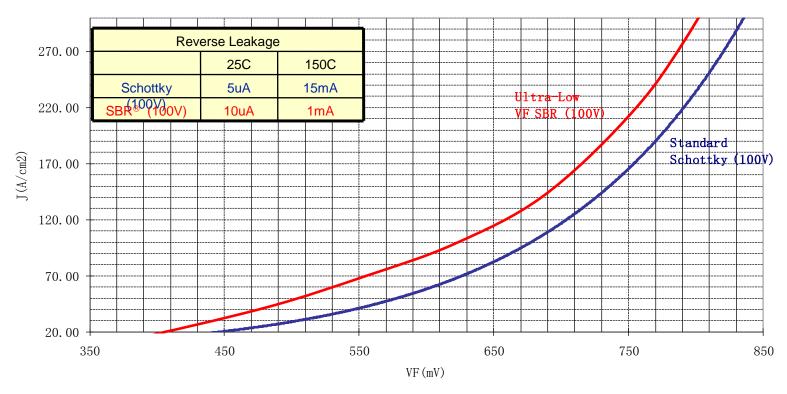
SBR® (Super Barrier Rectifier) Cell StructEire Years Out

### SBR® Forward Voltage (V<sub>F</sub>) Benchmark

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The Ultra-Low V<sub>F</sub> SBR<sup>®</sup> has significantly lower forward voltage (V<sub>F</sub>) than competitive Schottky devices.

#### **Current Density Comparison between Schottky and SBR**



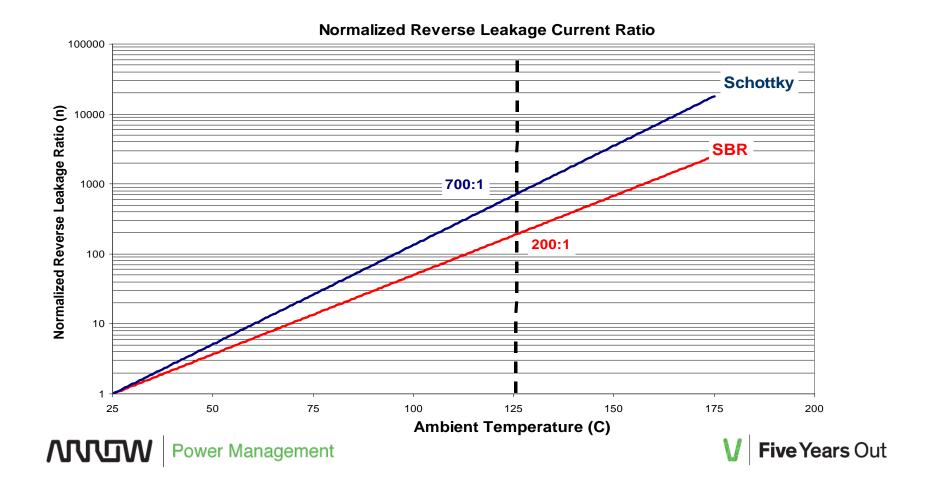




### SBR® Normalized Reverse Leakage

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SBR® technology has significantly lower normalized reverse leakage ratio at higher temperature than conventional Schottky devices

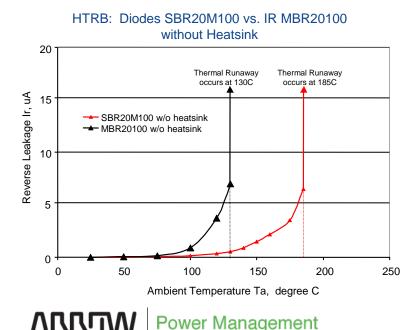


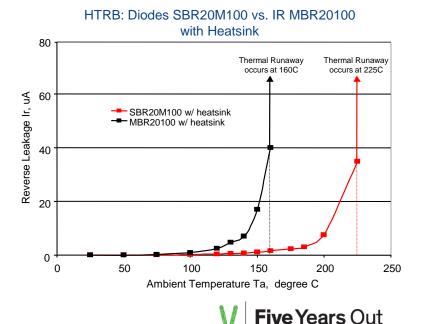
### Thermal Breakdown Comparison

107

The high temperature stability of the SBR® leads to significantly higher thermal runaway capability than a Schottky, resulting in...

- Higher operation reliability
- Higher temperature application usage
- Potential of eliminating the use of a heat sink





### SBR® Current Product Portfolio

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- SBR ® product portfolio include both small and large package outline
  - Small outline package
    - Leading edge performance for mobile phone & portable electronics applications
  - Large outline package
    - Most cost effective performance solution for power supply rectifier applications

			5	BR Cu	rrent Prod	duct Offe	ring an	d Devel	opmen	t			
	0.2A	0.2A - 0.7A	1A	1A	2A - 3A	3A -4A	1A - 3A	8A-10A	6A-10A	10A-60A	10-40A	10-60A	40-60A
Reverse Voltage	•	•	•										M
(V)	SOD-523	DFN1006-2	DFN1411-3	SOD-323	PowerDI-123	DFN3030-8	SMA	PowerDI-5	DPAK	D2PAK	ITO-220AB	TO-220AB	TO-247
20													
30	<b>@</b>			<b>©</b>	<b>@</b>								
40-45					<b>@</b>						<b>@</b>	<b>®</b>	
60									(8)	<b>@</b>	<b>@</b>	<b>®</b>	
100										8	<b>©</b>	<b>@</b>	
150										5.75		<b>@</b>	
200					<b>*</b>					<b>@</b>		<b>@</b>	
300										<b>©</b>		0	0
400												37	





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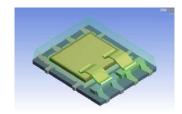
#### The Diodes Advantage

- Ultra-Low V<sub>F</sub> PowerDI5 and PowerDI5060 product families
- High forward surge rating (IFSM) to prevent large turn-on current spikes.
- Low maximum profile height of 1.15mm (PD5) and 1.1mm (PowerDI5060)
- Low thermal resistance.
- Targeted for SMPS for tablet PC, solar and smart mobile phones

PowerDI-5 Internal Construction

		•		V <sub>F (max)</sub>	I <sub>R (max)</sub>			
Part Name	V <sub>R</sub>	0	I <sub>FSM</sub>	I <sub>Rated</sub> @25C	V <sub>R,</sub> <sub>Rated</sub> @25C,	Package	Availabilit y	
	V	Α	A V		mA			
SBR15U60LPS	50	15	TBC	0.6	0.5	PowerDI506 0	Q4 2012	
SBR15U50LPS	50	15	TBC	0.52	0.5	PowerDI506 0	Q4 2012	

PowerDI5060



<sup>\*</sup>Forward current rating based on lead temperature derating.

- Introduction
- Diodes' Overview including Acquisitions
- Audio Amplifier Products
- Power Management
  - IC Product Solutions:
     AC:DC & DC:DC Switching Regulators, LDOs, Load/USB Power Switches,
     Current Monitors, Sync'FET drivers, Voltage References
  - Discrete Product Solutions:
     BJTs Optimized Gate Driver Products; MOSFETs; Super Barrier Rectifiers ("Next Gen' Schottky");
- ASMCC Application Specific Multi-chip Circuit Mixed Technology Assembly Capability
- Design Resources
   Application/Design Notes; Evaluation boards; Calculators; SPICE s/w



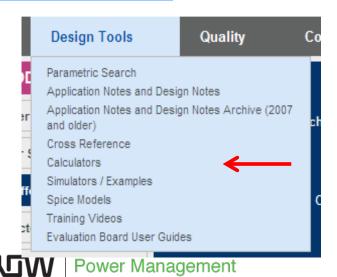
### **Design Resources - Navigation**

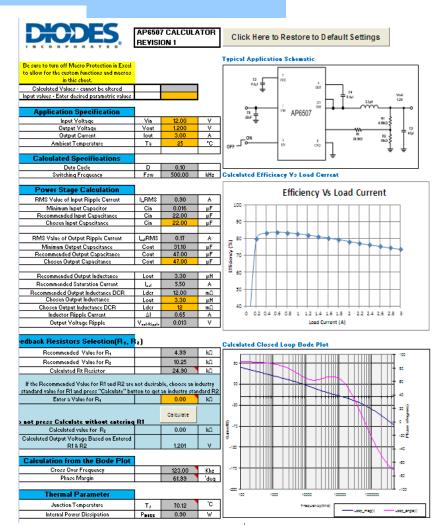
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### 1. Diodes Inc Homepage http://www.diodes.com/ 3. Example Calculator



### 2. Design Tools Menu





### **Design Resources – Simulation**

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### 1. Design Tools Menu



2. Simetrix Simulation Software download and circuit library

#### SIMULATOR SCHEMATICS

#### What is the Diodes Circuit Simulator?

- The Diodes Circuit Simulator is a free downloadable simulator which allows you to draw a circuit which can be tested in simulation prior to prototyping.
- By using Diodes Spice models, the designer can quickly determine the best components for the application
- The Diodes Simulator is an analog simulator ideally suited for power circuit blocks

#### Instructions

- Please click here to download Diodes Circuit Simulator »»
- 2. When prompted, save the file to your local disk
- 3. Run the installer
- 4. Once the application is installed, you may download and open as many schematics as you wish

This collection of simulations are design ideas that demonstrate circuits using Diodes solutions.

The circuits can be used as an aid before actual build of the circuit. However, as with all simulations not all aspects of real circuit performance is modeled and care should be taken with interpretation.

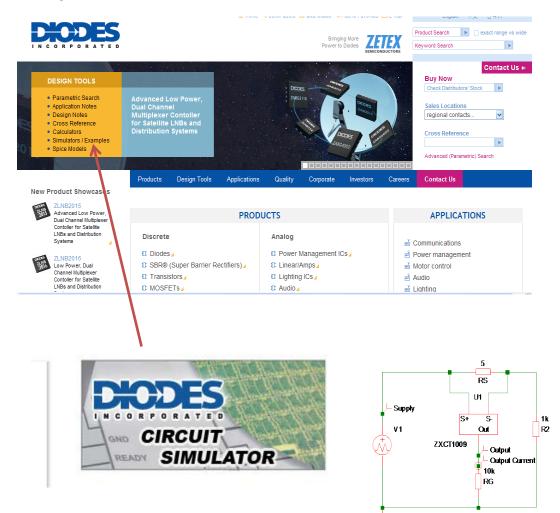




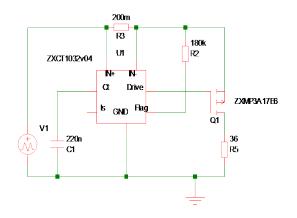


### Design Tools – Simulation Software

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#### 1032 model test 16oct08



AN39	Current measurement applications handbook.
AN40	Lithium ion battery charging using bipolar transistors.
AN45	High voltage current monitoring using the ZXCT series in power supplies.
AN46	Zetex' current monitors with PolySwitch™ overcurrent device
AN51	Precision voltage regulation for ultra-low noise applications
AN55	ZXCT1041 as a precision full wave rectifier
AN58	Designing with References - Shunt regulation
AN59	Designing with Shunt Regulators - Series regulation
AN60	Designing with Shunt Regulators - Fixed voltage regulators and opto isolation
AN61	Designing with References - Extending the operating voltage range
AN62	Designing with Shunt Regulators - Other applications
AN63	Designing with Shunt Regulators - ZXRE060 low voltage regulator
AN66	Designing with Shunt Regulators - AC amplifier
AN67	Designing with shunt regulators - mixing, adding or summing
AN71	Response time reduction of the ZXCT1009 Current Monitor



Some macro models available.... V Five Years Out



### Design Tools – Example – Current Monitors

- Applications note/handbook AN39
  - Current measurement
  - ZXCT product description
  - Applications information



- Application/Design notes:
- AN45 "High voltage current monitoring using the ZXCT series in power supplies"
- AN46 "The use of Zetex current monitors with the Polyswitch™ over current device."
- AN55 "ZXCT1041 as a precision full wave rectifier"
- AN71 "Response time reduction of the ZXCT1009 Current Monitor "
- DN77 "Transient and noise protection for Zetex ZXCT series current monitors"
- DN87 "Maintaining a short term supply rail to the ZXCT1081 during a short-circuit load or overload event"
- DN88 "The ZXCT1030 current monitor used as a GPS antenna switch with short circuit protection"

• Sales Leaflets 114

### **Design Tools – Example App/Design Notes**

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<u>DN80</u> Bipolar transistors for MOSFET gate driving applications. <u>http://www.diodes.com/\_files/design\_note\_pdfs/zetex/dn80.pdf</u>

DN90 ZXGD3101 Synchronous MOSFET controller improves energy efficiency of dual-output power supply

http://www.diodes.com/\_files/design\_note\_pdfs/zetex/dn90.pdf

AN18 Power MOSFET gate driver circuits using high current super-b transistors - 6A pulse rated SOT23 transistors for high frequency MOSFET interfacing. <a href="http://www.diodes.com/\_files/products\_appnote\_pdfs/zetex/an18.pdf">http://www.diodes.com/\_files/products\_appnote\_pdfs/zetex/an18.pdf</a>

<u>AN52</u> IGBT gate drive considerations in electronic lamp ballasts <u>http://www.diodes.com/\_files/products\_appnote\_pdfs/zetex/an52.pdf</u>

AN54 Energy Star® V2.0 compliant flyback converter using the ZXGD3101 synchronous MOSFET controller http://www.diodes.com/\_files/products\_appnote\_pdfs/zetex/an54.pdf





### **Design Resources – Evaluation**

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### 1. Design Tools Menu



### 2. Evaluation Board Listing



Eval Boards Index

#### **Evaluation Boards**

- AL3157F-EVM
- AL3157FSG WLEDs-EVM
- AL3158FSG RGBs-EVM
- AL3159FSG WLEDs-EVM
- AL5811EV1 User Guide
- AL5811EV2 User Guide
- AL5812EV1 User Guide
- AL5812EV1 User Guide (Chinese)
- AL5812EV1 User Guide (Korean)
- AL5812EV1 User Guide (Japanese)
- AL5812EV2 User Guide
- AL5812EV3 User Guide
- AL8400EV1 User Guide Issue 1
- AL8805EV1 User Guide Issue 3
- AL8805EV2 User Guide Issue 1
- AL8806EV4 User Guide Issue 2
- AL8806EV6 User Guide Issue 1
- AL8807AEV1 User Guide
- AL8807AEV3 User Guide
- AL8807EV1 User Guide Issue 1
- AL8807EV2 User Guide issue 2
- AL8807EV3 User Guide Issue 1

- AP8802EV1 User Guide Issue 4
- AP8802EV2 User Guide Issue 5
- AP8802EV3 User Guide Issue 6
- . AP8802HEV2 User Guide Issue 1
- AP8803EV1 User Guide Issue 1
- API9221EV1 User Guide Issue 3
- DLD101EV1 User Guide Issue 1
- HALLSENSOREV1 User Guide Issue 2
- LEDC001 User Guide Issue 1
- LEDC002 User Guide Issue 2
- LEDC002 Oser Guide issue.
- LEDC003 User Guide Issue 1
- LEDL001 User Guide Issue 1
- LED0001 User Guide Issue 1

#### Partial listing

- PAM2304 User Guide
  - PAM2305D User Guide
  - PAM2306 User Guide
  - PAM2310 User Guide
  - PAM2312 User Guide
- PAM2316 User Guide
- PAM2319 User Guide
- PAM2320 User Guide

- ZXCT1084EV1 User Guide Issue 1
- ZXCT1086EV1 User Guide Iss1
- . ZXCT1107EV1 User Guide Iss 1
- ZXCT1109EV1 User Guide Issue 1
- ZXCT1110EV1 User Guide Issue 1
- ZXGD3101EV1 User Guide Issue 2
- ZXGD3101EV2 User Guide Issue 1
- ZXGD3102EV1 User Guide Issue 4
- ZXGD3102EV1 User Guide Issue 2
- ZXHF5000EV2 User Guide Iss 1
- ZXLD1320EV1 User Guide Issue 2
- ZXLD1320EV3 User Guide Issue 2
- ZXLD1321EV1 User Guide Issue 1
- ZALD 132 ILV 1 OSEI Guide ISSUE
- ZXLD1321EV2 User Guide Issue 2
   ZXLD1322EV1 User Guide Issue 1
- ZXLD1322EV2 User Guide Issue 2
- \_\_\_\_\_
- ZXLD1350EV3 User Guide Issue 1
- ZXLD1350EV4 User Guide Issue 1
- ZXLD1350EV6 User Guide Issue 1
- ZXLD1350EV7 User Guide Issue 1
- ZXLD1352EV1 User Guide Issue 1
- ZXLD1356EV1 User Guide Issue 1





### Design Tools – Example E



















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